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RURAL STUDIES

BOOK TWO

RURAL STUDIES

BY

J. C. W. HOUGHTON, B.A.

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BOOK I	154 pages	3	0
BOOK II	192 pages	3	6
BOOK III	*in preparation*		
BOOK IV			

RURAL STUDIES

BOOK TWO

by

J. C. W. HOUGHTON, B.A.
Lecturer at the City of Leeds Training College

Illustrated with photographs,
and line drawings by
ARNOLD BOND

With thanks to those
who first found
'The Fields' and 'The Wood'

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PREFACE

THIS is the second book of a four-year course in rural studies. The theme of the course is perhaps best expressed in the words of an old countryman for whom a few hours in the city proved more than enough: 'Let 's get back to the fields where there 's life!'

Emphasis is laid throughout on a direct approach to the activities of country people and the materials they handle in their daily round. Although the course does provide a good foundation in rural studies for those pupils who wish to proceed further with their education in some branch of rural technology, the subject-matter has been chosen and presented with a view to its educational rather than its instructional value. Vocational training is more properly the province of the farm institute, and the method of observation and interpretation adopted in these books aims rather at a widening of interest and sharpening of inquiry.

Each book contains enough material for one lesson per week throughout the school year; and the topics are arranged to correspond with seasonal activities, the more formal classroom work being confined to the winter months when work in the fields is at its slackest. Where experiments and demonstrations are described, apparatus of the simplest kind has been suggested. It was necessary to bear in mind that some schools—not being in possession of flasks, beakers, and so on—would need to make use of improvised apparatus; and the materials described have proved to be both convenient and effective.

Many of the exercises are graded to provide practice in written expression, and have been designed for use in the English lesson. Should it be possible for all the exercises to be done in one book —which could, perhaps, be called 'My Country Book' —each year's work might well comprise a quite desirable record of inquiry and achievement; and the work resulting from the pupil's own observations would constitute a simple but valuable environmental study.

I am grateful to Mr. H. W. Marsh of J. M. Dent & Sons Ltd. for his kind help throughout the preparation of this book and for his valuable suggestions concerning the text. I am also indebted to the following who have kindly provided photographic illustrations:

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J. C. W. HOUGHTON.

MARSH GREEN
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I

The Air and Breathing

Breathes there a man, with soul so dead,
Who never to himself hath said,
  This is my own, my native land!
Whose heart has ne'er within him burn'd,
As home his footsteps he hath turned,
  From wandering on a foreign strand!

Sir Walter Scott.

A being breathing thoughtful breath,
A traveller betwixt life and death.

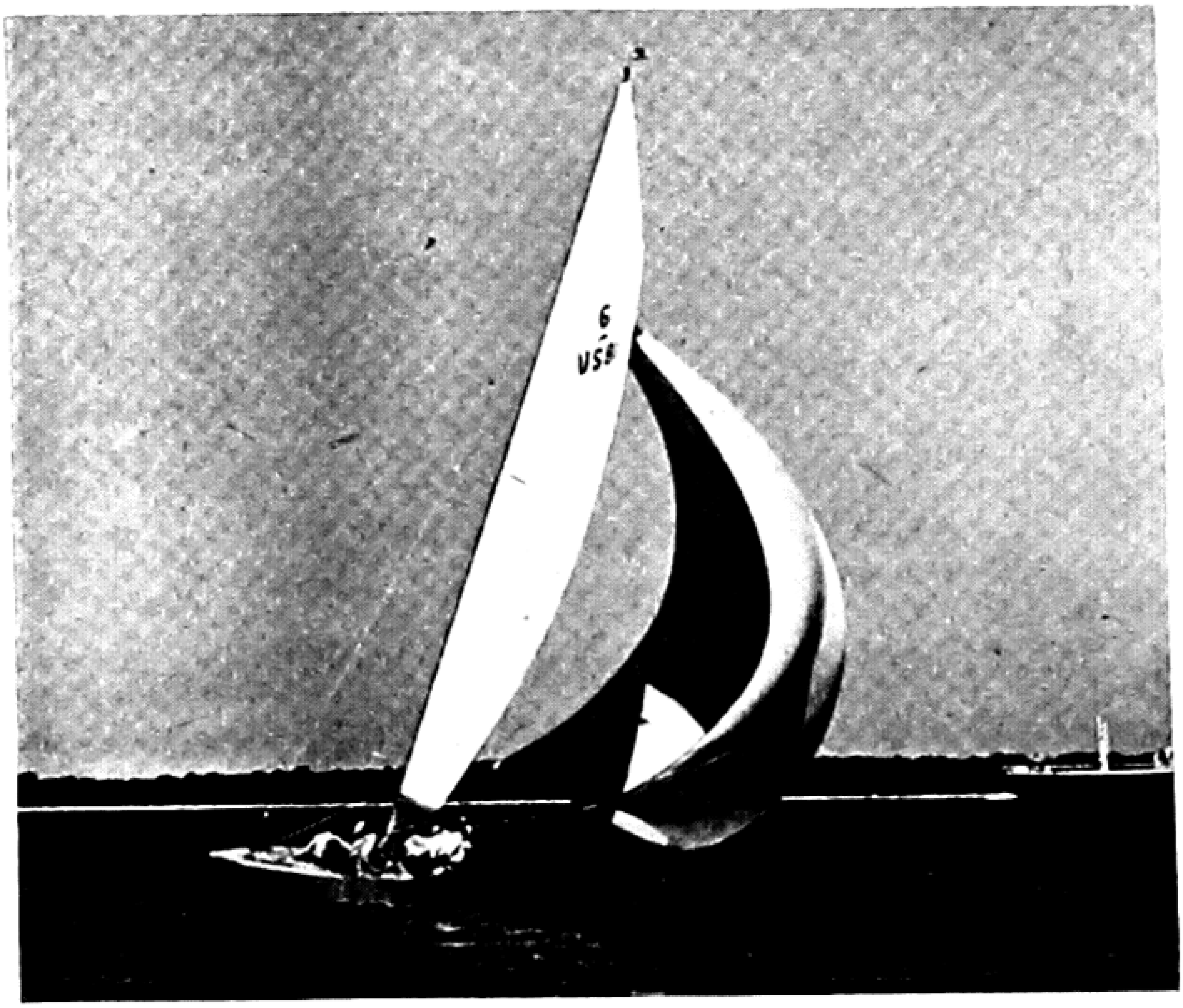
William Wordsworth.

ALTHOUGH we cannot see the air in the atmosphere, we know it is there because we can feel it rushing through our noses when we breathe in quickly; and on a windy day we can see the effect of the moving air on trees and waves and dust. What is the air? It isn't a liquid like water or milk or petrol; if it was it would feel wet like a liquid, and if you had a small quantity of it you would be able to pour it into a glass and see how much of it you had. Air is something that seems to fill up all the spaces where there are no liquids or solid things like bricks. We give a special name to such a substance: we call it a *gas*. You are quite familiar with the gas that comes from the gas-works and that burns when you

---

N.B.—For Experiments Nos. 7 and 8 you will need some peas that have started to sprout, so put a handful of dry peas on some damp flannel as soon as you can so that they will be ready.

light it. You know what happens to this gas when you turn on the tap and forget to light it. It doesn't just pour out of the gas jet on to the floor; it behaves just like air and goes all over the room—you can smell it all over the place. That is why we call it a gas. Perhaps you thought that there was no other gas but this? There are very many different sorts, however. Some of them will burn like coal-gas, and some of them won't burn at all. There are some gases that you can see because they are coloured—yellow gases, brown gases, green ones, and so on—and there are many others that are both colourless and



We cannot see the air; but we can certainly see some of the things it does.

quite invisible. There are several colourless gases all mixed together in the air we breathe, and we are going to examine some of them more carefully.

EXAMINATION OF CARBON DIOXIDE

Experiment 1. To do this experiment the class will need a siphon of soda-water that is about three-quarters full, two feet or so of rubber tubing that will just fit the spout of the siphon, a deep bowl, five or six one-pound jam jars, five or six pieces of thick cardboard to fit over the jars, some water, and some vaseline.

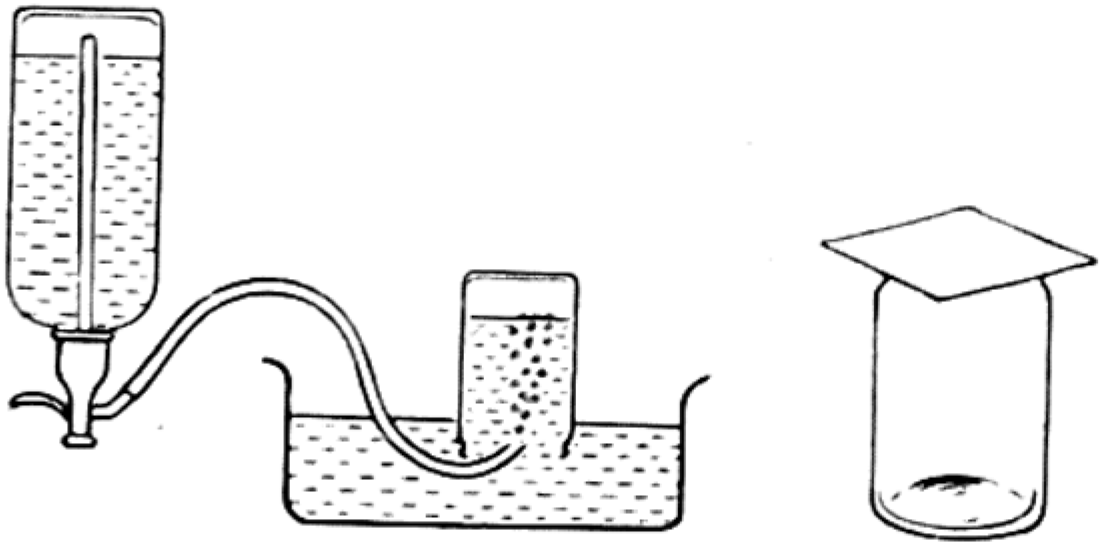


Fig. 1. The gas in the covered jar was collected from the siphon of soda-water. What gas is it?

First of all fit the rubber tube on to the siphon spout (Fig. 1) and hold the siphon upside-down. When you press the tap of the siphon in this position, no soda-water comes out, but you will notice some kind of gas rushing through the tube. This is the gas we are going to examine, and we must collect some of it.

In order to do so put the jam jars into the deep bowl and cover them well with water so that each one is quite full. We do this in order to get all the air out of the jam jars. You should now smear plenty of vaseline over one side of each piece of cardboard, and all is ready.

With one hand hold a jar upside-down—taking care not to let any air get into it—and with the other hand hold the end of the rubber tubing beneath the water and under the mouth of the jar. When the siphon tap is pressed the gas will bubble up into your jar. When the jar is full of the gas, stop the bubbling and place a piece of cardboard over the open end. To do this you will have to put the cardboard under the water, and you should put the greasy side on the jar so as to seal it. When you are sure that it is properly sealed you can put the jar, right way up, on the table. You now have one jar full of the gas and no air can get in. Fill and cover the other jars in the same way, and you are now ready to examine this gas.

1. Some gases, like coal-gas, have a smell. Take the cover from one of the jars to see if this gas has a smell. You will soon find that it has not.
2. Light a wooden spill or paper taper, and first of all hold it in an empty jar that has not so far been used. It goes on burning quite merrily. Now, while it is still burning, hold it inside one of the jars filled with the gas. The light goes out immediately! Do this again with another jar of the gas to make *sure* there is no mistake. You get the same

result again. This proves to you that the gas in the jars is not ordinary air.

3. Take an empty jar that contains ordinary air and pour about half an inch of *lime-water* [1] into it. Now cover it with cardboard and shake it up. Do exactly the same with a jar of the gas. Is there any difference? You will quickly see that there is. The gas from the siphon turns the lime-water very milky indeed, whereas the ordinary air has very little effect at all.

We can now write down four important things that will enable us to become detectives and recognize this gas whenever we find it:

(*a*) It has no colour.
(*b*) It has no smell.
(*c*) It won't let things burn.
(*d*) It turns lime-water milky.

We call this gas CARBON DIOXIDE, and you should learn the name carefully.

Is there any carbon dioxide in ordinary air? Yes, the air does contain a small proportion of carbon dioxide, but the amount is so small that lime-water does not detect it. We can show this in the following way:

Experiment 2. Put about an 'inch' of lime-water into a small jar. Now use a bicycle pump to bubble air through it—put the end of the connection tube into the lime-water and start pumping slowly. There is no milkiness at all.

---

[1] To make lime-water: Put some slaked lime into a bottle and then fill up with water, shake it, and cork it up. After a day or two pour the clear liquid which is now *lime-water* into a clean bottle.

Experiment 3. Now use the pump connection tube to bubble your own breath through some clear lime-water. The liquid very quickly turns milky.

If we think about these two experiments, we shall soon see that there is little or no carbon dioxide in the air we breathe in, but a good deal in the air we breathe out. Somewhere inside us we must *make* carbon dioxide during our breathing! That is quite true and we shall learn more about it later in the chapter. In the meantime, we will examine another gas.

EXAMINATION OF OXYGEN

Experiment 4. For this experiment you will need either a special glass flask or a tin with a small neck, and a cork to fit it tightly. A tin that has contained liquid metal polish or some such liquid does very well, but you should carefully burn or scrape off all the paint before you begin the experiment. You must bore a hole through the cork either with a special instrument called a cork-borer, or by piercing it with a red-hot knitting-needle. This hole must be just big enough to receive a piece of metal tubing about the same thickness as the spout of the soda-water siphon (Fig. 2). Any motor garage will let you have the metal tube, which should be about three inches long.

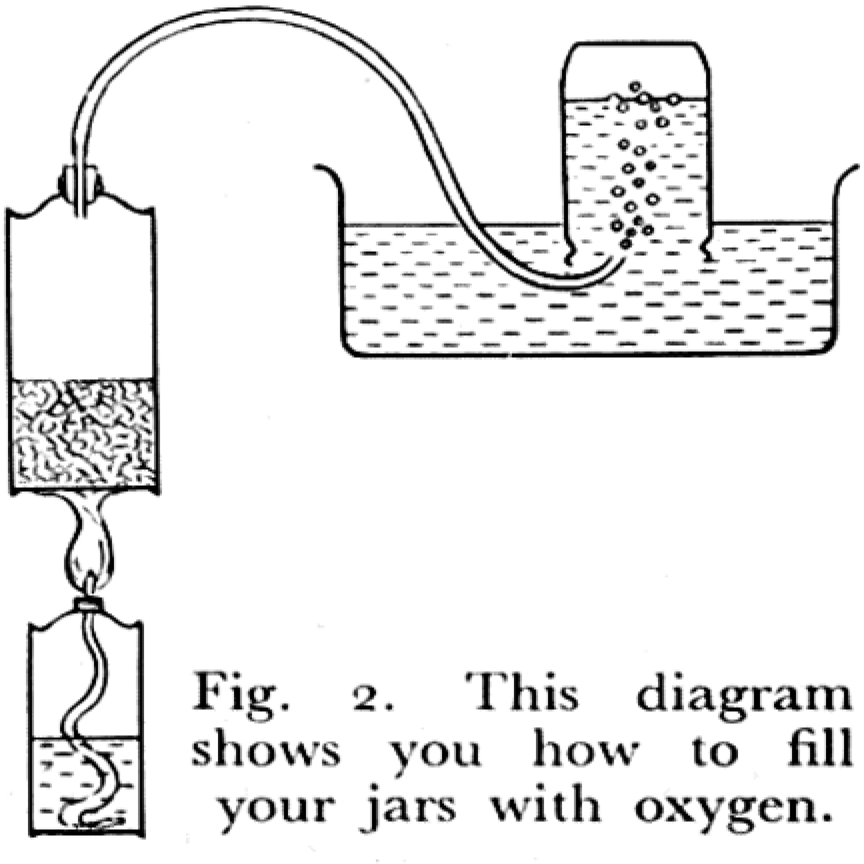


Fig. 2. This diagram shows you how to fill your jars with oxygen.

In addition, you will need all the materials that you used for Experiment 1, together with about

(*a*) One ounce of potassium chlorate, and
(*b*) Half an ounce of manganese dioxide.

You can get these from the chemist.

You will also need a gas burner or a spirit-lamp. If there is not a suitable gas burner in school you can easily make a small lamp for methylated spirit from another small metal-polish tin. Fill the tin with methylated spirit and roll a long wick from some cotton wool. Put this in through the neck, leaving enough outside to light. Everything is then ready:

Mix the potassium chlorate and manganese dioxide together thoroughly and put the mixture into the tin. Fix the rubber tubing and arrange everything else—the jars and the bowl of water, etc.—as in Experiment 1. Now heat the tin *very gently* with your flame. You must on no account let it become red hot; it is important to do no more than 'lick' the container with the gas or spirit-lamp flame. A colourless gas will come through the tube, and you will collect several jarfuls of this as you did before. (It is best to do the experiment on a large stone slab or stone floor, so that if anything goes wrong there is no danger of fire. Or the bench could be protected with a sheet of asbestos.) Let us now examine the gas in the jars. You will soon see that, like carbon dioxide, it is colourless, and has no smell. Does it stop things burning too? Let us see:

1. Light a wooden spill, or a taper, and then blow it out so that it just glows. Put the glowing end into a jar of the gas. The result is

quite startling, for the splinter bursts into flame again. This gas is *not* carbon dioxide because it makes things burn more vigorously than ever!

2. If you can do so, get some iron wire that is not much thicker than cotton or thread; heat it to redness, and while it is still glowing dip it quickly into a little powdered sulphur and then plunge it into a jar of the gas. You will be surprised to find that even iron will burn in this gas when you do this!
3. Take a small piece of sulphur or some powdered sulphur and place it on a small piece of tin. Set it alight and drop it into a jar of the gas. Again you will see how vigorously the gas makes things burn.
4. Put some lime-water into one of the jars and shake it round. Does the liquid turn milky? There is no milkiness at all.

From these tests you will be able to write down four important things that will enable you to detect this gas at any time:

(*a*) It has no colour.
(*b*) It has no smell.
(*c*) It makes things burn vigorously.
(*d*) It does not turn lime-water milky.

The gas is called OXYGEN.

Is there any oxygen in the air? There is quite a lot. About one-fifth of the air is oxygen, and it is the oxygen in the air that makes things burn.

WHAT IS BURNING?

No doubt you have often seen a coke fire burning—the sort of fire that a road worker has in a brazier near his hut when he is on watch through the night. The coke is a substance called CARBON. (The black part of a match that has 'gone out' is also carbon, and so is soot.) In order to burn and keep hot, the coke in the brazier uses up some of the oxygen in the air; and as time goes on the coke slowly disappears. We say it burns up. Now let us ask ourselves a very interesting question: If the carbon and the oxygen get used up during the burning, where do they go to? Do you think they are completely destroyed? Or are they turned into some other substance? Think of a burning candle. That, too, seems to disappear. Does the wax cease to exist after the candle has burnt away? The answer is that the coke, or the wax, or whatever is burning, joins with the oxygen of the air and one or more new substances are formed. When we burn any substance that contains carbon—coke, methylated spirit, wax, coal-gas, etc.—the carbon *unites* with oxygen to form carbon dioxide gas. We can prove that this is so by doing the following experiment.

What happens to the coke when it 'burns away'?

Experiment 5. Light your spirit-lamp, or a gas burner or a candle, and hold a jar mouth downwards over it so that it becomes filled with the hot air coming from the flame. After a few seconds slip a piece of greasy cardboard over the jar and set it upright on the table. Make sure it is properly sealed with the card. When it is cool, pour in some lime-water and shake it round. What you see tells you that there *was* some carbon dioxide in the gas rising from the flame. We say that carbon dioxide is a *product* of the burning. It is quite a strange thought that the solid black carbon in a coke fire can unite with oxygen and be changed into a gas. It really means that the coke or carbon goes into the air, though we can't see it because it is disguised as carbon dioxide. We can remember what happens quite easily if we write it down in this way:

$$\text{Carbon} + \text{Oxygen} = \text{Carbon dioxide}$$

You would never guess that there was carbon in wax or in coal-gas. You cannot see the carbon in these things, just as you cannot see it in the gas we call carbon dioxide, but it is there all right. Most of the materials that you see burning contain carbon, so that, generally speaking, carbon dioxide is a product of burning. Of course, if you burn things like sulphur or iron in which there is no carbon, there will be no carbon dioxide produced. Burning of this sort, however, is less common; and you need not bother about it at present.

Have you ever wondered why placing a board or a large sheet of paper in front of a fire-grate makes the fire burn more readily? The paper causes more air to go up through the fire, and so there is more oxygen passing through the sticks and coal. This allows more burning to go on and the fire blazes away quite merrily, and gets quite hot.

Remember : Whenever anything *containing carbon* burns, these four things happen:

(*a*) Oxygen of the air is used.
(*b*) The burning substance is used up.
(*c*) Carbon dioxide gas is formed.
(*d*) Warmth is produced.

WHAT HAPPENS WHEN WE BREATHE?

Experiment 3 has shown us that when we breathe, carbon dioxide is somehow made inside us. We know that the air that goes into our lungs contains a good deal of oxygen—how do we know this?—and that the air we breathe out contains much more carbon dioxide. Not only is carbon dioxide being made; oxygen is being used up also. This is the same sort of thing that happens when carbon burns. Let us examine breathing a little more closely.

If you stand about on a wintry day you soon begin to feel cold; but if you begin running about, *you begin to breathe more quickly and more deeply*, and as you do so you get warmer and warmer until, even on the coldest day, you are all aglow. Can you notice the similarity between a person breathing and a fire burning? In each case:

(*a*) Oxygen of the air is used;
(*b*) Carbon dioxide gas is formed; and
(*c*) Warmth is produced.

Even when you are sitting quite still, or lying asleep in bed, the warmth of your body comes from your breathing. It certainly begins to look as though breathing *is* a kind of burning. And, indeed, that is just what it is. There are no flames inside us, of course! Instead of making hot flames, the 'burning' that goes on inside us makes our bodies warm, and it makes us energetic.

There is still something that we have not accounted for, however. When a coal fire or a candle is burning, the coal or the wax is used up and the carbon in these substances unites with oxygen to form carbon dioxide. Is anything used up in the same way inside us when we breathe and make carbon dioxide? This *must* be the case, otherwise the carbon dioxide could not be made; and indeed, our breathing does use up a fuel that we have in our bodies. This fuel comes from our food. Some of the things we eat are changed into sugar by our digestion, and it is this sugar that 'burns' when we breathe. Sugar contains a good deal of carbon, and this carbon unites with the oxygen we breathe in and helps to form the carbon dioxide we breathe out. You did not know, perhaps, that the sweets and sugar that you eat come out again in your breath! (Not all the food you eat is used in this way, of course. Some of it is used to make new muscles and new hair and skin, and so on. Food, you see, has two uses.)

Here is an experiment that proves to us that sugar does contain carbon.

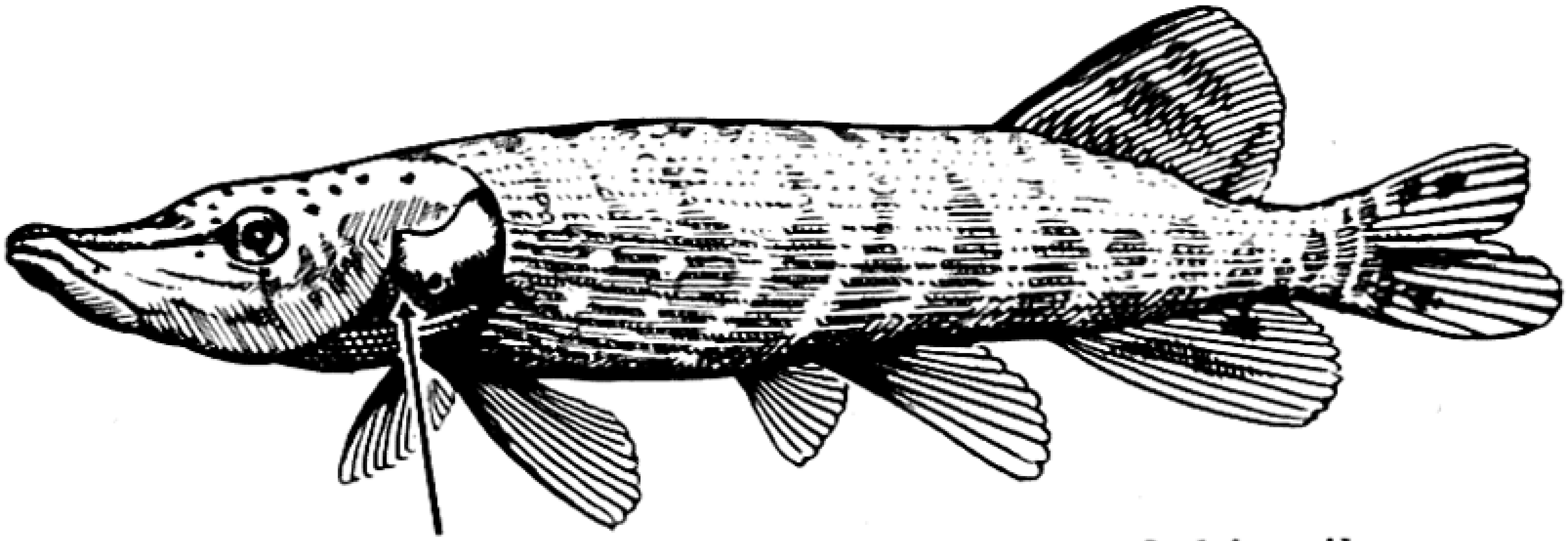
Experiment 6. Place a tin lid over a gas flame and put a little sugar into it. The heat soon begins to change the appearance of the sugar, and you will very soon see some of the black carbon that was in the sugar before you began heating it. If you continue to hold the tin over the flame the sugar will 'disappear' altogether, just as the sugar in our bodies is used up when we breathe.

You will now be able to understand why we feel very hungry indeed on a cold day or when we have been doing hard work. On these occasions we breathe in more air than usual. The extra oxygen that we breathe in uses up more of the sugar in our bodies. When the body begins to get short of sugar it tells us so by making us feel hungry. If we did not take in more fuel by having a meal we should not be able to go on working or keeping warm. Of course, there are always some reserves of food in the body, but if we starved ourselves completely the body machine would eventually stop working altogether—even our hearts would stop beating, and we should die. You see, we must have both fuel (from our food) and oxygen (from the air we breathe) in order to keep our body machine working. A motor-car engine is rather similar to our bodies in this way, though, of course, it is much less complicated; it needs fuel (petrol) and oxygen (from the air) in order to keep running. Our bodies 'burn' up food; the petrol engine burns up petrol—and carbon dioxide is produced in both cases. We breathe it out, and the engine sends it out through the exhaust pipe.

Remember that *breathing is a kind of burning* which

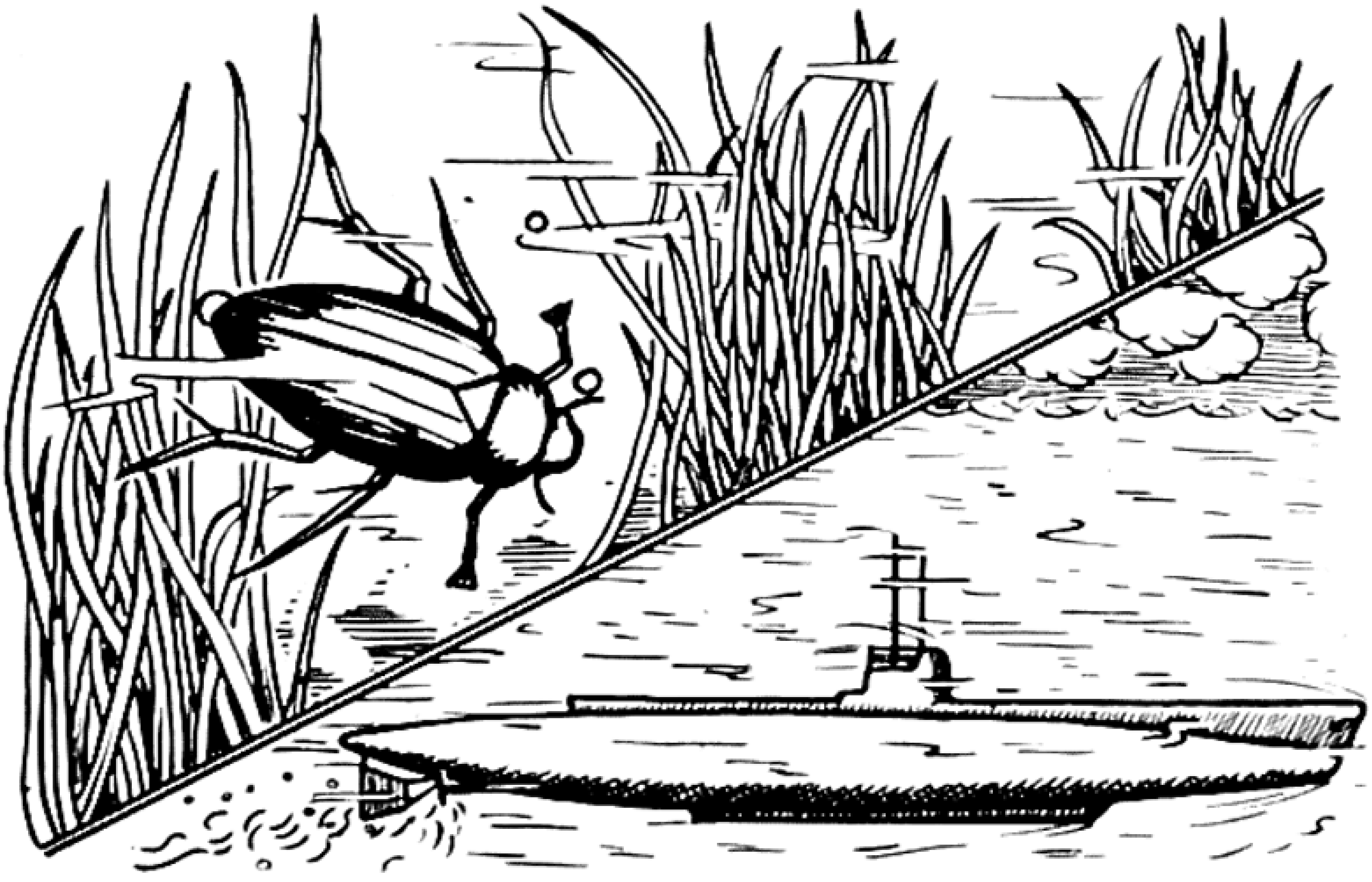
(*a*) Uses oxygen.
(*b*) Uses up sugar in our bodies.
(*c*) Makes carbon dioxide.
(*d*) Makes us warmer and more energetic.

The same thing, of course, happens when any animal breathes, and anything that stops a man or an animal from breathing will cause death. This is what happens when an animal is drowned or suffocated. No oxygen can get into the lungs and so breathing stops. You may wonder why fish do not drown. They are animals and they need to breathe. How do they get their oxygen? There is oxygen in most water—it is dissolved in it so that you would never guess that it was there—and the fish has two very special *organs* that it uses for getting the oxygen from the water in which it lives. These special organs are called *gills*, and if you lift up the flaps on the side of a fish's head, you will be able to see the gills underneath. They look like bundles of fine pink thread. If for any reason these gills were prevented from working, the fish would drown! And, indeed, this does sometimes happen when men are fishing.



The arrow points to the gill covers of this pike.
Why do fish have gills?

Some water creatures do not have gills, however, and they have to come to the surface of the water in order to get supplies of air. You should watch a small water-beetle in a jar for a while. It comes to the top of the water from time to time and collects a small bubble of air, which it carries down with it into the watery depths. The bubble glistens like a jewel, and the beetle uses this air for breathing as it swims about. When it is all used up it is necessary for the beetle to come up for a fresh supply. This is rather similar to what happens in a submarine. The submarine sometimes remains submerged for many hours, and the oxygen inside it soon gets used up by the crew and changed into carbon dioxide by their breathing. If there was no more oxygen to be had the men would either have to surface the ship or suffocate. They have learnt a lesson, however, from the water-beetle. Whenever the submarine is at the surface, fresh air is pumped into special tanks where large quantities of it are stored under pressure—in much the same way that the air in a bicycle tyre is under pressure. This air is released into the submarine when it is submerged, so that there is no danger of suffocation. Much the same sort of thing happens in high-flying aeroplanes. There is much less air high up in the



All creatures need oxygen for breathing. How are water-beetles and submarines supplied with oxygen?

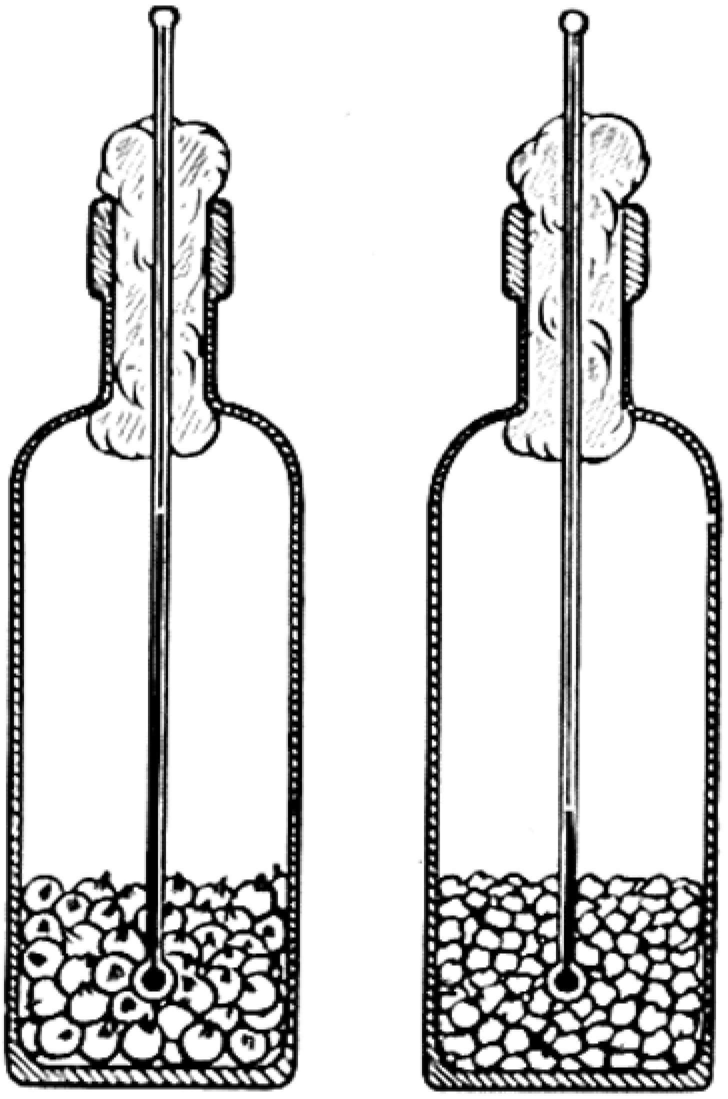
atmosphere than there is at sea level, so that if an aeroplane goes up to about 15,000 feet, the crew need to take a supply of oxygen with them. This is carried in special steel bottles and the airmen breathe it through special masks strapped on to their faces. Serious things can happen if they forget to turn on the oxygen—the pilot loses all sense of what he is doing and the aeroplane is soon out of control. Oxygen, you see, is essential if animals are to go on living.

DO GREEN PLANTS BREATHE?

We have seen that all animals breathe and we know something about what breathing is. Plants, too, are living things. Perhaps they breathe also? If they do they will use up oxygen and they will send out carbon dioxide, and warmth will be produced. Let us try to find out by experiment whether these things happen.

Experiment 7. For this experiment you will need some pea seeds that have just begun to grow. About thirty or forty of these should be put into the bottom of a small jar and left to stand in a warm room. After an hour or so, pour in a little lime-water and shake it round. You will see that it turns milky. What does this prove? It seems that the growing seeds are breathing because they send out carbon dioxide.

Experiment 8. You are now going to find out whether the growing peas get any warmer as they grow, because—if they *are* breathing—we should expect them to. For the experiment you will need two pop-bottles, two thermometers like the ones shown in the picture, and some cotton wool. Set the bottles side by side in a warm room, but out of the sun. Put some growing pea seeds into one bottle so that you have a layer about three inches deep. Into the other put three inches of dry pea seeds fresh from the packet. Now place a thermometer into each bottle and bury the bulbs (the bottom ends) in the seeds. Close the neck of each bottle with a tight plug of cotton wool. Tomorrow morning you will begin to note the temperature shown on the two thermometers, and you should keep on looking at them about every hour during the day to see whether there is any difference.


The swollen peas in the first bottle are beginning to grow. Can you say why they are getting warmer?

You will find that there is. The growing pea seeds are much warmer than those that are dry. This is because they are breathing.

Plants—like animals—do breathe; they take in oxygen and turn it into carbon dioxide which they send out into the air again. They do this day and night. You may wonder what part of green plants does the breathing since they have no nose, lungs, or gills! Most of the breathing is done by the *leaves*, though stems and roots do breathe also. Do you remember that roots need air in the soil as well as water? You now know why. How does the air get into the leaves and how does the carbon dioxide get out? There are millions of tiny holes in the leaf—so tiny that you can't see them without a microscope—and the breathing goes on through these. You will get some idea of how numerous these holes are when you are told that a single cabbage has more of them in its leaves than there are people in the whole world! Each hole is called a *stoma*.

A plant does not need to keep so warm as a human being, nor does it require so much energy in order to keep on living, so that it does not need to breathe in as much air as we do. Nevertheless, even the tiniest plant must keep on breathing all the time. If it stopped breathing it would die.

THINGS TO DO

(1) Write a composition entitled 'What Happens when the Fire Burns.'

(2) Write single sentences in answer to the following questions:

- (*a*) What two substances unite to form carbon dioxide?
- (*b*) What do we call this uniting process?
- (*c*) What else is produced by the process as well as carbon dioxide?
- (*d*) Why do coal and wood get used up when they burn?
- (*e*) What substance detects carbon dioxide?
- (*f*) Why does a stronger draught make the fire burn more rapidly?
- (*g*) How do we know that there is oxygen in the air?

  - (*h*) How do we know that breathing is a kind of burning?
  - (*i*) What is used up in our bodies when we breathe?
  - (*j*) Why can fish breathe?

(3) What are the four important *properties* of carbon dioxide?
(4) What are the four important properties of oxygen?
(5) What four things take place when coke burns?
(6) What four things take place when animals breathe?

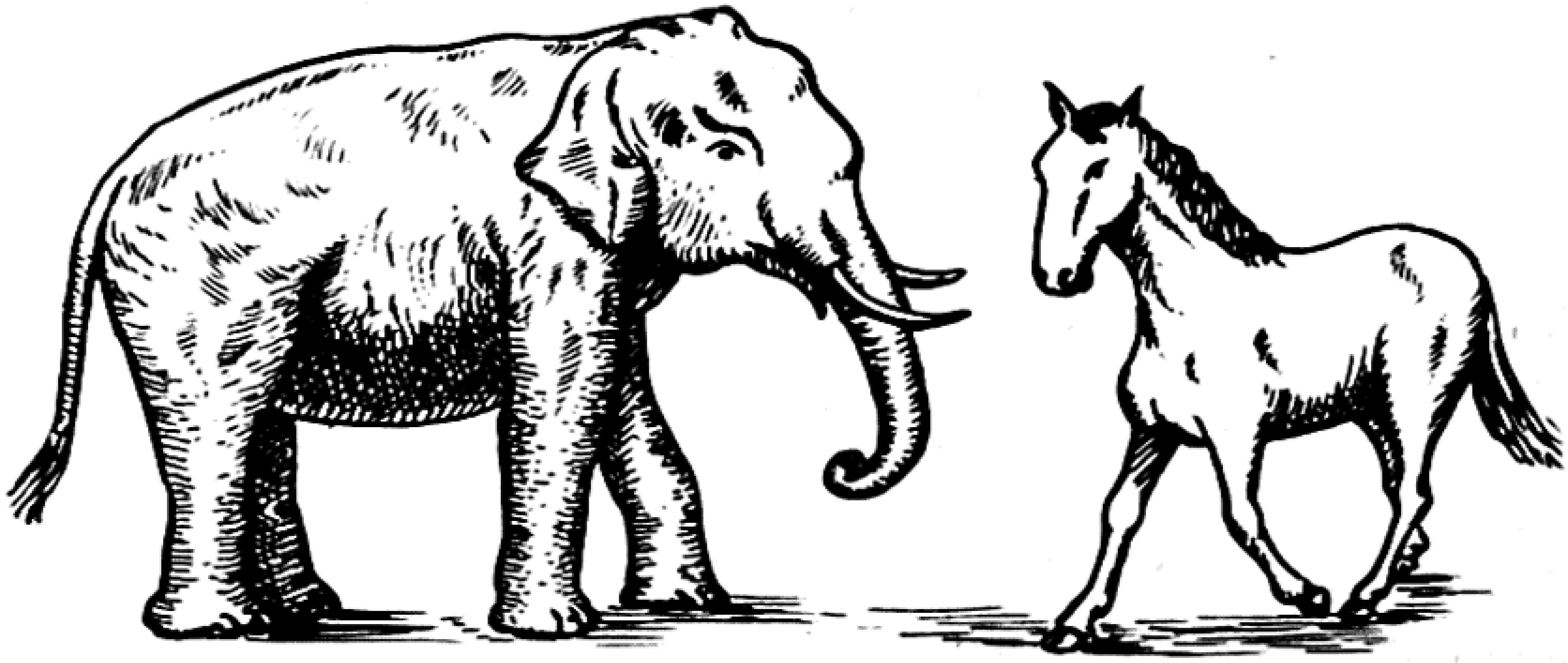
2

How Long Do Plants Live?

For the earth is the Lord's, and the fulness thereof.

I CORINTHIANS, X. 26.

YOU learned last year that seeds contain baby plants, and that nature produces them in very large numbers so that there shall always be enough new plants to replace those that die. Have you ever wondered how long a plant can go on living? You know that some kinds of animal live much longer than others. A horse is quite an old fellow at twenty years, but an elephant may well go on living for much more than a hundred years. Many animals, of course, live for a very much shorter time than either the horse or the elephant. Indeed there are some that never



At twenty years of age a horse is getting quite old; but an elephant is still a young fellow!

live for as much as even one whole year. Did you know, for example, that many of those honey-bees that you see going from flower to flower collecting nectar and pollen in the summer months live for only six or seven weeks, and that the mayfly lives for only one day? Most insects, in fact, have quite short lives. There is, you see, a great variation in the *life-spans* of different animals. Is this true of different kinds of plant also? Let us think about it.

Field poppies and wheat are both dead in less than a year. What do we call such plants?

ANNUAL PLANTS

There are very many plants that, like the honey-bee you have just read about, never live to be even one year old. Think of the wheat that your farmer friend grows. Even when the seed is sown in the autumn, the crop is ripe before a year has gone by and all the plants are quite dead. The same is true also of broad beans, lettuce, groundsel, chickweed, field poppy, and shepherd's purse. Can you think of any others like this? Such plants are called *annuals*, and when they come to the end of their short lives every part of them dies—root, stem, leaves, and flowers as well. Only the seeds live on. Some of the annual weeds like groundsel and chickweed go through their *life-cycle* in a very short time indeed—much less than a year, and that is why they can be so troublesome. They have to be killed when they are tiny plants or *seedlings*, because if they are allowed only a few weeks in which to grow they shed thousands of fresh seeds on to the soil, thus making it more 'foul' than ever. The fewer weed seeds there are in the soil, the fewer weeds will come up, so that the farmers and gardeners have to take care never to

Why is it important to kill weeds while they are still young?

allow annual weeds to go on growing until they come into flower. Here is an old country saying that reminds us of this:

One year's seeding.
Seven years' weeding.

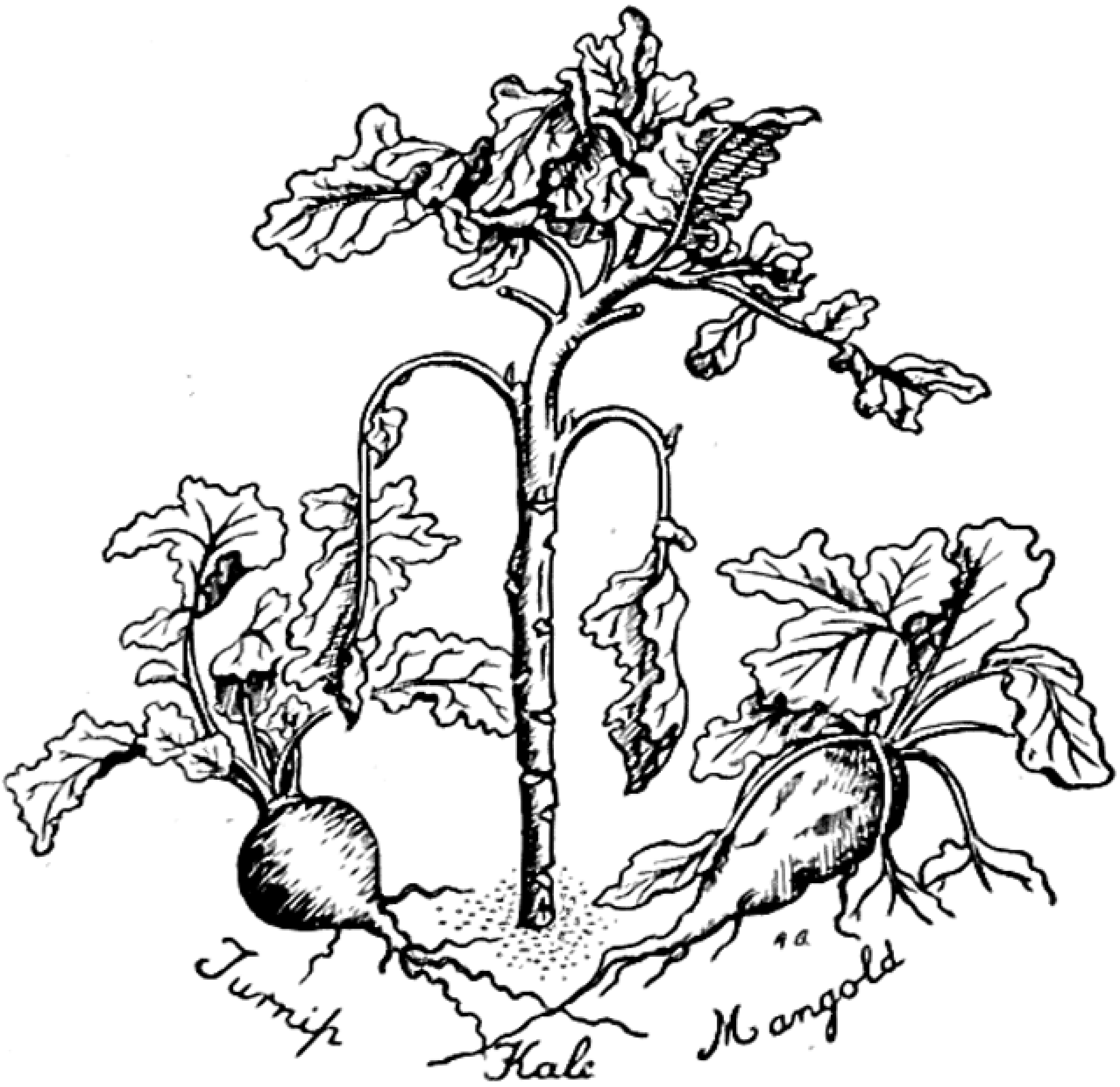
This means that if the seeds from one 'crop' of annual weeds get into the soil, there will be enough seeds to go on producing weeds for many years! You can now understand just why corn crops like wheat let the soil get so full of weed seeds—once the crop is growing, the farmer cannot get at the annual weeds with his hoes or harrows, and they are able to grow to the flowering stage and scatter their seeds on the ground.

The mould boards on this plough turn the soil right over—and bury all the annual weeds.

Do you remember the lesson about stubble cleaning? As soon as the corn is cut and harvested, the farmer stirs the soil with a cultivator or some such implement in order to get some of these fresh weeds to grow. When they have come up, he kills the young plants by ploughing them in. Of course, the gardener can get on to his land more often, so that he is not faced with the same difficulty. Good gardeners always kill annual weeds when they are quite small—usually with a hoe and sometimes by hand-pulling. Farmers and gardeners who allow their weeds to seed are not only laying up trouble for themselves, they are also being very unfair to their neighbours. When you remember the way in which many kinds of seed are carried about by the wind, you will see why. The plumed fruits of the groundsel are easily carried far and wide by every passing breeze, and the seeds of many weeds are so light that they are easily spread about by the wind even when they have no special plumes. Of course, this is true not only of annual weeds but of many other kinds too—however long they live.

SOME FOOD STORERS THAT LIVE FOR TWO SUMMERS

Let us now examine the life story of some plants that live for longer than one year, but usually die before they are two years old. A good example is the turnip. The turnips that are to be seen growing in the fields in summer and autumn have come from seeds that were sown in the previous spring; but they are not yet in flower, and you rarely see a crop of turnips 'go to seed.' Why is this? The answer is that the farmer uses the crop before the plants have reached the age of flowering. If he left them in the field until next summer, they would flower quite freely and this is what seed-growers have to do in order to get turnip seeds for sale. When the seeds have been produced the whole plant dies, just as the annuals do, but the difference is that in this case the flowers and seeds do not appear until the plant is more than one year old. We call any plant that does this a *biennial*, which really means a plant that lives into its second year before it 'sets seed' and dies. On the farm all the 'root' crops—turnips, swedes, mangolds, sugar-beet, and kale are biennials. Let us try to find out why the farmer grows so many plants of this kind.



For what purpose do these biennial plants store food in their swollen parts?

If you think about all the garden and farm crops that are biennials you will notice that in each case a part of the plant is swollen. Turnips and sugar-beet have swollen roots, farm kale has a swollen stem, and a cabbage has thickened, fleshy leaves inside the 'head.' Why does the plant have these swellings? *They are parts of the plant where food can be stored.* When the plant is growing in its first year it makes much more sugar in its large leaves than it requires for ordinary growth, and this sugar is stored in the swollen roots or stems or leaves. Nature intends this store of food to be used by the plant in the following year to produce the new shoots, flowers, and seeds! Can you see why the farmer or the gardener has to use the crop before it flowers? He wants the store of food—either for his stock, as in the case of mangolds and turnips and kale, or to sell for *human consumption*, as in the case of sugar-beet and, maybe, some of his turnips. If he didn't lift his root crops before flowering most of the stored sugar would be used up and the crop would be useless.

Let us pause for a moment to make a list of the three important things we have so far learnt about sugar:

1. All sugar is made in the green parts of plants—mostly in the leaves.
2. The sugar we eat is used up when we breathe, and the carbon in it helps to make the carbon dioxide we breathe out.
3. The sugar we get from sugar-beet was really intended by the plant for making leaves, flowers, and seeds in the second year of its life.

You should learn these three facts by heart.

PLANTS THAT LIVE FOR MANY YEARS

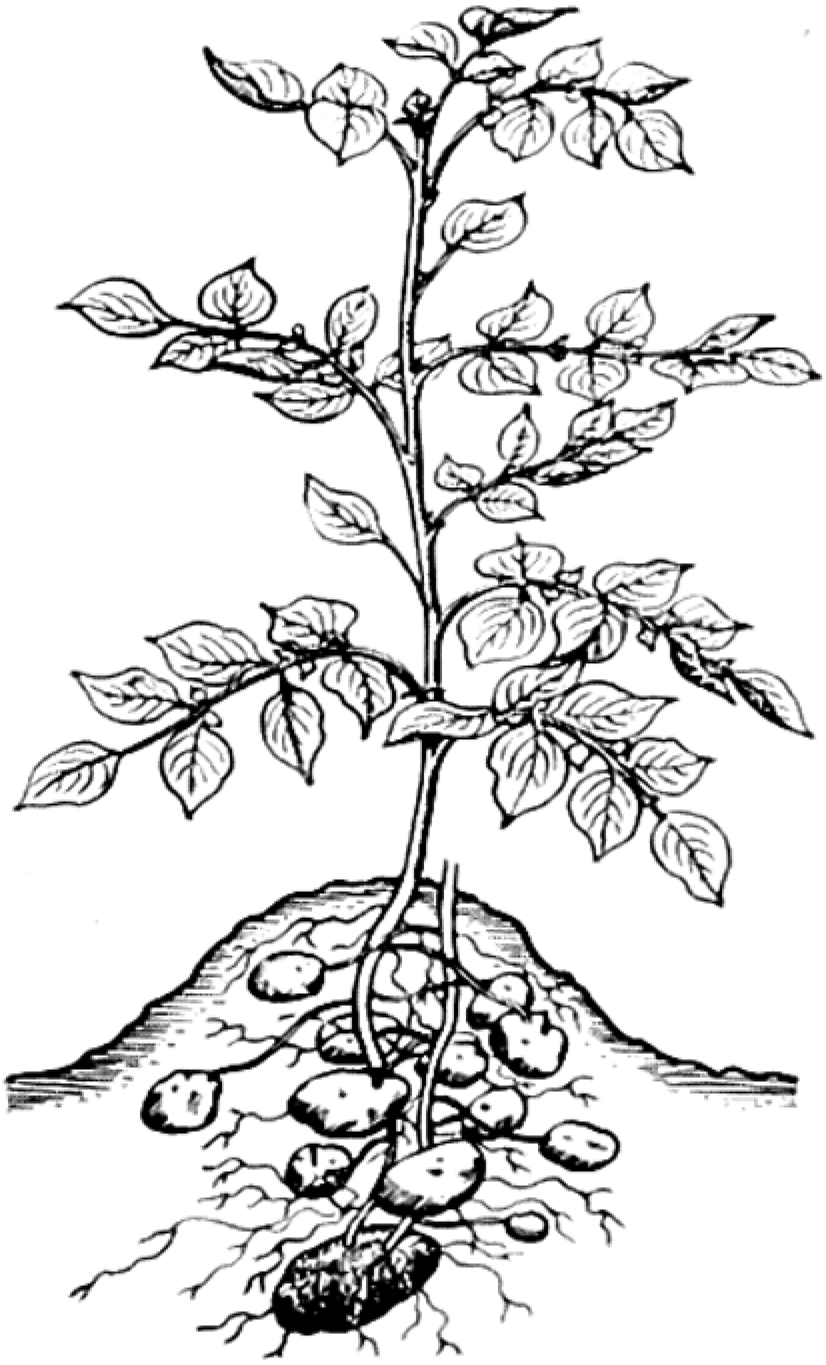
There are very many plants that go on living for many years. You know that trees live to a great age—much longer than human beings as a rule—and some of the plants in the flower garden will come up each year without any fresh seeds being sown. Michaelmas daisies, outdoor chrysanthemums, and many others come up 'on their own,' as we say, year after year. Even though such plants seem to die in the autumn, there is some part of them under the soil that keeps alive right through the winter and sends up new shoots in the spring. Plants that are able to do this are called *perennials*, which is a short way of saying that they go on living year after year. Trees and shrubs are called *woody perennials*, and plants like Michaelmas daisies, that lose their stems and branches each autumn, are called *herbaceous perennials.*

You have just learnt that the green leaves of biennial plants make more food than they need for ordinary growth, and this surplus is stored in the swollen part. Perennial plants make extra food in the same way, and store it up in readiness for the spring; but they can go on doing this year after year, whereas biennial plants like the turnip can do it only once. Woody perennials store this food in their twigs, branches, and trunks; but the herbaceous plants keep their stores underground.

It will perhaps surprise you to know that the underground parts in which herbaceous perennial plants store this food are not always roots by any means. Sometimes the food is stored in UNDERGROUND STEMS and sometimes even in UNDERGROUND LEAVES! By the time winter approaches, all the stems and leaves and flowers that have been growing above the soil during the summer and autumn are dead, and in the case of garden plants they have usually been cut off and removed to the rubbish heap. But under the soil, safe from the winter frosts, are the food stores from which the new shoots will be made when spring returns again. Just think of the enormous amount of food that must be stored over the winter in the soil of even the smallest woodland! Out of this plant larder—out of these stems and roots and bulbs that are swollen and fleshy with all the treasured stores of summer—will come the green pageant of spring. The many ferns and grasses, the bluebells and wood anemones—all, indeed, that makes the springtime scene so gay, has been prepared for in the previous summer. We can truly say that nature is not dead in the cold days of winter—under the soil she is very much alive, and awaiting only the magic touch of spring.

Can you think of an example of a crop plant that has underground food stores like this? There are very many indeed, but perhaps the one you know best is the potato. During the summer the leaves of the potato plants that you see in the fields and gardens are busy making sugar. Some of this sugar is taken down to special stems growing beneath the soil, and on these stems the potato *tubers* are found. The sugar passes into these growing tubers, where it is changed into *starch*. This is the food store that the plant uses in the following year to send up new stems and leaves. Of course, in the case of the potato, mankind comes along and eats up most of this stored food himself; but this is not what the plant intended by any means!

The potato is a very clear example indeed of an underground food store. You must always try to remember what the store is for—*it contains the material out of which the plant will make new growth in the following spring.*



'Seed potatoes' are not real seeds. What are they?

Do you notice that this is a second way in which perennial plants can increase their numbers and replace those that die? So far we have learnt only about the baby plants in seeds, and we know that before the seeds can be produced, pollen has to get to the pistil of the flower. But this second way of *reproduction* does not require anything of the kind. There is no baby plant at all in this case, and the potato tuber is not a true seed but just a special part of the original plant that has broken itself away. The potato plant does have real seeds, but these are quite small and come from the starry flowers that you see in most potato fields. The farmer never grows his potatoes from these true seeds, however. It has been found better to use the tubers for planting.

Let us examine some of the many wild flowers that grow from swollen underground stems of this kind.

WOOD-SORREL

CUCKOO-PINT

LADY'S-SMOCK

These three wild plants are perennials.

The familiar wood anemone[1] that carpets the woods and hedgerows with its delicate white flowers in the early spring has a swollen stem just under the surface of the soil, and so do the lady's-smock, cuckoo-pint (or wild arum), coltsfoot, and wood-sorrel. If you dig one of these plants out of the soil, you will be able to see their underground stems for yourself. They are quite fleshy, and you will often be able to see both buds and roots growing out of them. If you wish to find the swollen food stores of the bracken fern, you will have to dig down quite deeply. This is why the farmer finds it very difficult indeed to get rid of bracken—his plough will not reach down to the underground stems. Some of the wild plants you will examine do not grow underground stems, but store their food in special roots instead. The swollen underground parts of the celandine and dandelion, for example, are roots.

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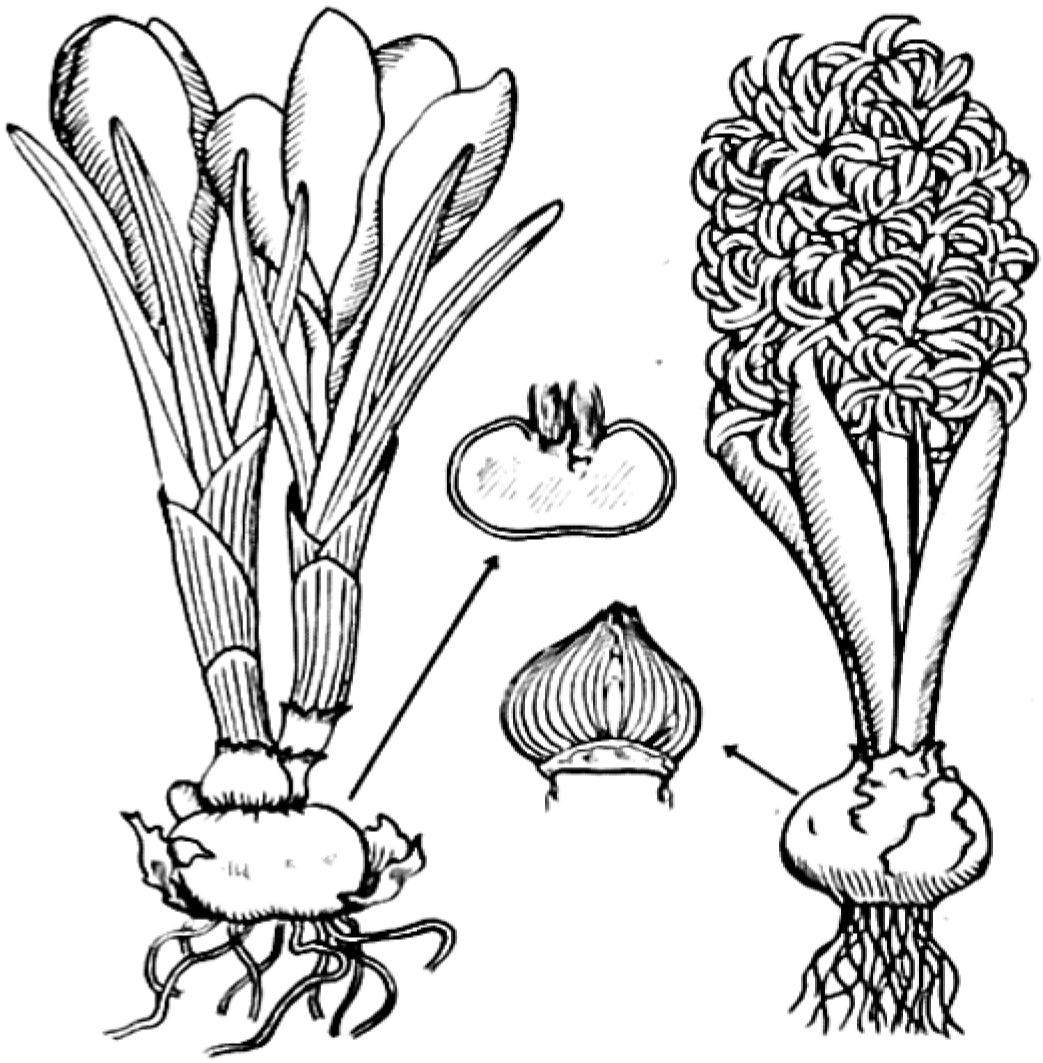
[1] See the picture on page 34.

BULBS AND CORMS

Perhaps you have already realized that the bulbs and corms that we put into bowls and pots in the autumn are good examples of the larders of perennial plants. Crocuses and gladioli grow from *corms*, whereas daffodils, tulips, and hyacinths grow from *bulbs*. What is the difference between these two kinds of food store? If we cut open a bulb we find that it is made up inside of a number of separate layers that are very swollen and juicy. The whole bulb is full of the food material that will be used to make the leaves and flowers when the plant begins to grow again in the spring. Each layer is really part of a leaf that has been grown underground for storing food. We shall find, however, that a corm is very different. It is all in one piece, and if you remove the papery coverings you will easily see that it has small buds growing on it. What do these buds tell you? Do you remember that buds are found only on stems as a rule? *The corm is a swollen stem.* You may think that it is just like the potato and that we ought to call it a *tuber*. The tuber, however, always grows from a branch stem of the plant, whereas the corm always grows from the main stem. That is why we give them different names.



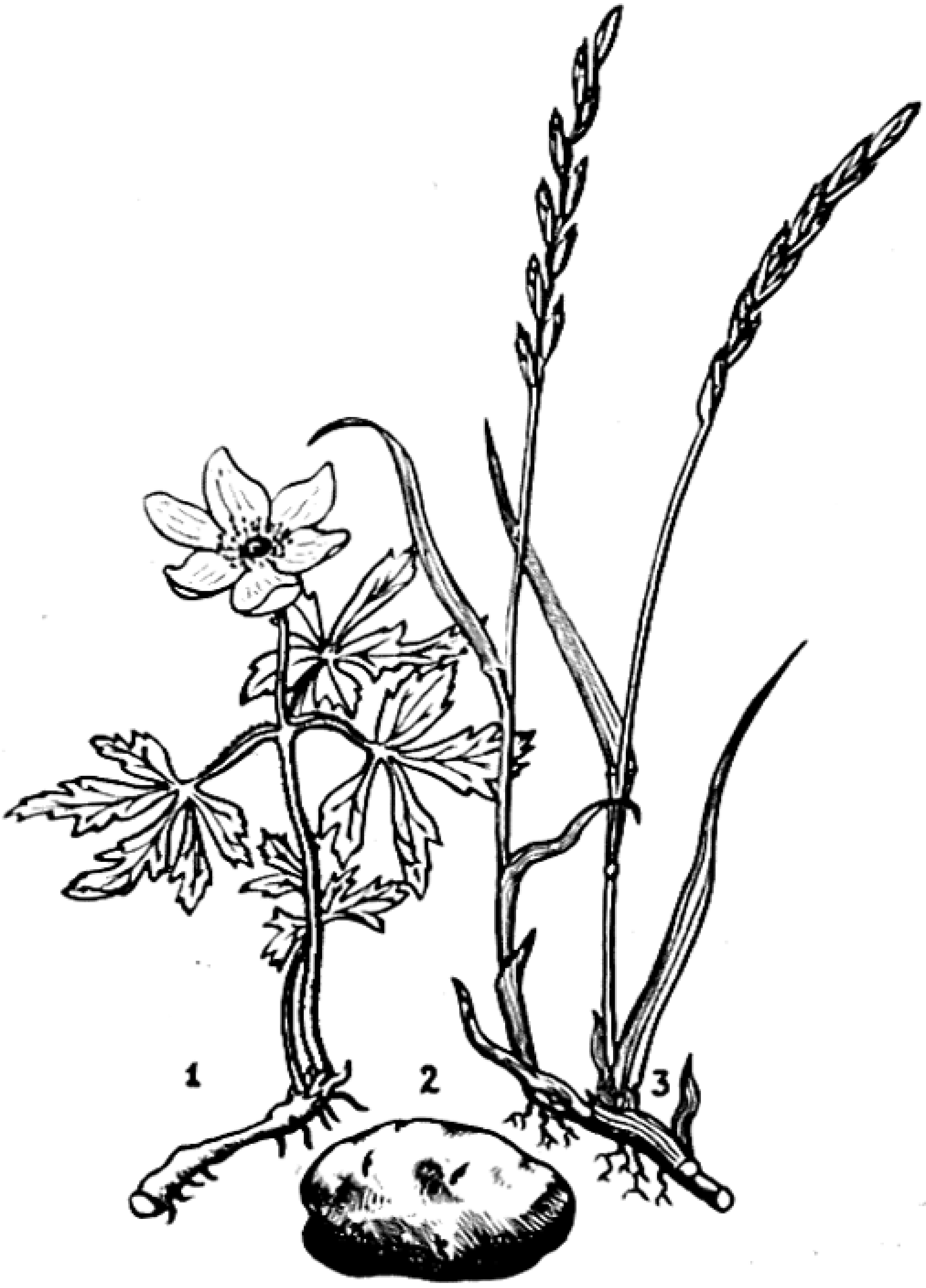
Fine blooms are quickly produced from the food stored in crocus corms and hyacinth bulbs.

Experiment. If you wish to see whether the plant really does use up these food stores when it is developing new shoots, you should grow a hyacinth bulb on a jam jar full of water—or on a glass jar made specially for the purpose. Fill the jar with water and place the bulb on top, so that its base nearly touches the water. If you keep it in a dark, cool cellar, roots will very soon begin to grow down into the water and the leaves will begin to sprout. When these leaves are 2½ inches high, place the bulb in the light. It will take several weeks for the plant to develop, and you should feel the bulb from time to time to see whether it is getting any less fleshy. (Put a small piece of charcoal into the jar. This keeps the water clean and sweet smelling.) If you cannot do the experiment in this way, you should dig up a crocus just as it begins to flower and examine the corm. Has it gone any smaller? You will find that it has, and you will notice, if you look carefully, that a tiny new corm has already begun to grow on top of the old one. Nature is already looking ahead to next spring!

If you have crocuses, or any other corms or bulbs growing in the garden, you must take care not to destroy the leaves when the flowers are 'over.' Can you give a good reason for leaving them? Remember that it is the green leaves that make the new food—the flower has nothing to do with that at all—and if you want the new corms and bulbs to store enough food for next year's flowers, you must let the leaves go on doing their work. Very often the leaves of such things as daffodils and crocuses look untidy after the flowers have gone, and the gardener sometimes knots them together to keep the garden neat. He never cuts them down; he knows that they are busy storing food in their bulbs and corms! It would be better really to leave them entirely alone. If ever you are picking bluebells you will wish to take some of the leaves also, but you should not take too many. Remember that the leaves make the sugar for next year's bulbs. And you should also take care to break the stem of the bluebell near the soil level. If you pull at the stem you tear it away from the bulb, which may die as a result, and you might easily destroy your favourite bluebell patch in this way! So be careful.

A TROUBLESOME PERENNIAL WEED

You have learnt something about the ways in which farmers and gardeners destroy annual weeds. In one way or another they root up the young seedling weed so that the whole plant—root, stem, and leaves—is killed. Are there any biennial or perennial weeds? If there are they will have underground food stores of some kind, and they must be very troublesome indeed, because even if the stems and leaves of such weeds are cut off with a hoe new shoots can grow from beneath the soil. Unfortunately there are many weeds like this. One of them is especially troublesome. If you have ever helped your father to get *couch grass* out of the garden you will be well acquainted with the long fleshy underground stems of this plant. If the soil is badly *infested* with couch grass, these creeping stems are so thickly matted that it is very difficult indeed to



The wood anemone (1), potato (2), and couch grass (3) store food in underground stems. How do we know they are stems?

remove them. The usual way on the garden is to dig the ground over with a fork and to give each forkful a good shaking. In this way the soil is riddled away from the tangled mass of couch grass *rhizomes*—as the creeping underground stems are called—and these must then be thrown on to a heap and burnt. If you live near to a farmer on whose fields couch grass is to be found, you may have seen him at work in the autumn pulling the weed out with cultivators and harrows. If you have, you will no doubt have noticed the many small bonfires that he makes up and down the field for burning the rhizomes. He knows very well that he can't leave them about the land. If he did, all his work would be in vain, for every piece would grow again. There is a special name given to this kind of weed killing—it is called autumn cleaning. It is always done in the autumn and it is used mainly for getting rid of couch grass. Try to find a rhizome of this weed. You will be able to see that it *is* a stem because it has buds growing on it.

Do you remember what you learnt in the first book about the natural food of wild pigs? You were told that their diet included the roots of plants for which they grubbed about in the soil. You now know that they were feeding on the special food-storing roots and stems of biennial and perennial plants, and it is very probable that these things formed an important part of the diet of primitive man also.

THINGS TO DO

(1) Write a composition entitled 'Underground Food Stores.'

(2) Write single sentences in answer to the following questions:

(*a*) Why is chickweed called an annual plant?
(*b*) When should annual weeds be killed?
(*c*) What do we mean by 'dirty' or 'foul' soil?
(*d*) Why does a corn crop cause 'dirty' land?
(*e*) Why is the turnip called a biennial plant?
(*f*) Why do most biennials have a swollen root?
(*g*) Why does the farmer call his root crop a 'cleaning' crop?
(*h*) Why do some plants have underground stems?
(*i*) Why is the potato tuber not a true seed?
(*j*) How can you tell whether an underground food store is a swollen stem or a swollen root?
(*k*) Why must you allow the leaves of bulb plants to go on growing after the flower is dead?

(3) Use the following words and phrases in sentences of your own: life-span; annual plant; life-cycle; biennial; perennial; tuber; reproduction; rhizome; infested; autumn cleaning.

(4) Write a short paragraph entitled 'How to pick Bluebells.'

(5) Make a list of the crops, including grass and clover, grown on the farm you visit, and write down their names under three headings:

Annual	*Biennial*	*Perennial*

(6) Use a trowel or a large pocket-knife to dig up as many different underground food stores of wild plants as you can. Wash each one carefully and bring it for the nature table. The whole class should get at least twenty kinds. Each one should be labelled with its name and the place where it was found.

After these have all been seen, find a small patch in the garden and set them so that you can watch for the shoots in spring. In this way you can make your own wild garden.

(7) Make careful drawings in your book of any five of the above specimens.

(8) Write a short paragraph explaining the difference between stubble cleaning and autumn cleaning.

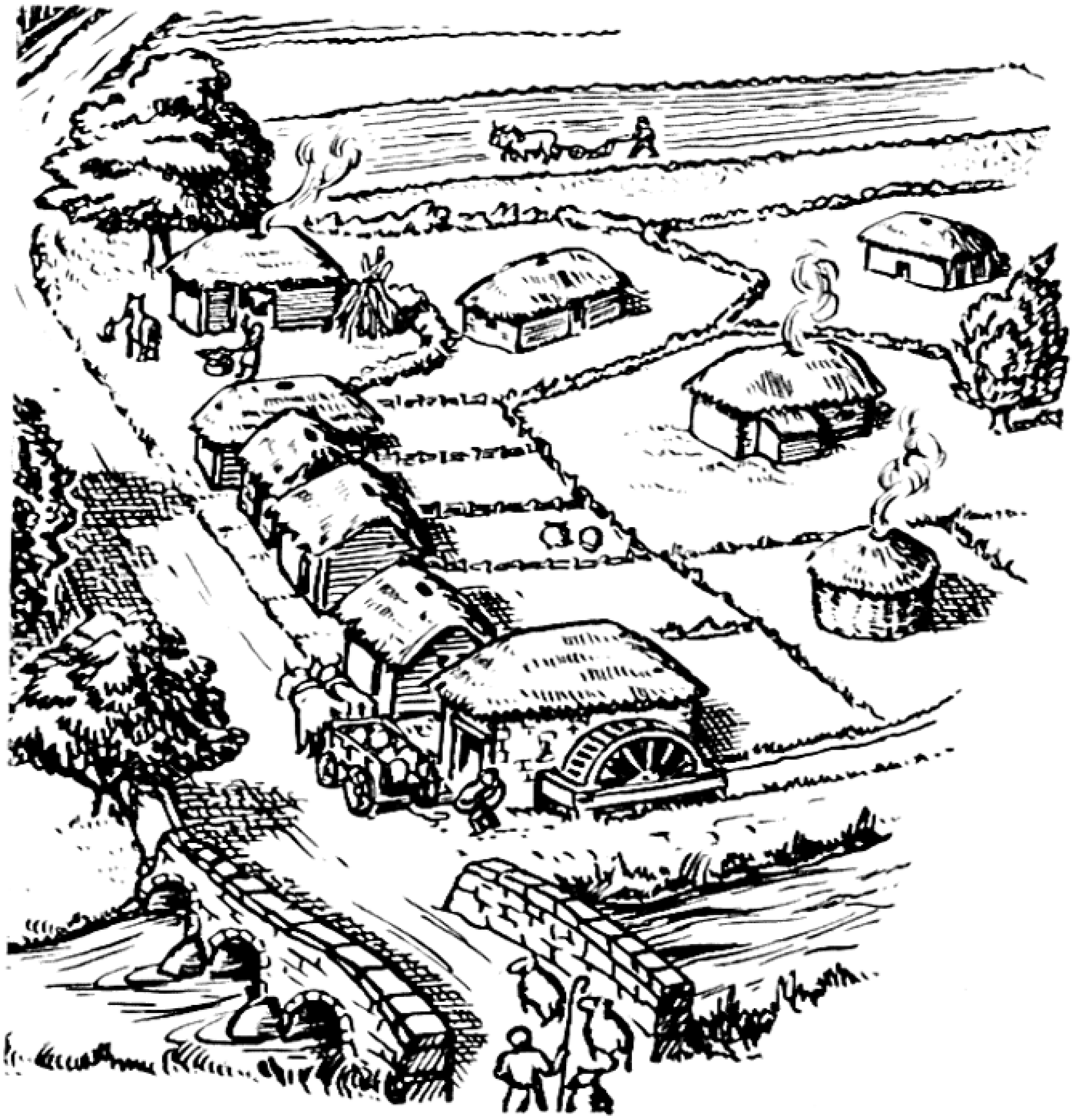
3

The Beginnings of Farming in England

And you, good yeomen,
Whose limbs were made in England, show us here
The mettle of your pasture.
Henry V (SHAKESPEARE).

On either side the river lie
Long fields of barley and of rye
That clothe the wold and meet the sky,
And thro' the field the road runs by
To many-tower'd Camelot.
The Lady of Shalott (TENNYSON).

VERY probably, the mention of a log cabin brings to your mind a picture of the huge forests of western Canada, where the lumberjacks of to-day use the plentiful timber of their woodlands to build their own shacks. But you must remember that the cottages in Britain were made of wood long before there were any white people living in Canada at all. The swineherd's cottage where King Alfred is said to have let the cakes burn would be made of logs, and if you had lived in Britain in those days your own home would probably have had split logs for its walls, a roof thatched with either straw or turf, and a floor made of dried mud. Everyday things in those far-off days were very different indeed from what we have to-day; almost everything that the ordinary people ate or drank, all the clothing they wore, and the things they needed to use in their home and on the land were produced in the small villages in which they lived—and the necessary materials—the corn, the meat, leather, wool, timber, and so on came mostly from their farmland or from the surrounding forest. Nowadays farmhouses are dotted about the countryside and each one is surrounded by its own fields, but for many centuries there were no separate farms of this sort in Britain. Each village was built in the middle of a huge stretch of farmland, and all the farmers lived in wooden cottages in the village street. Behind each cottage in the larger villages was a group of small



Peasant homes of bygone Britain.

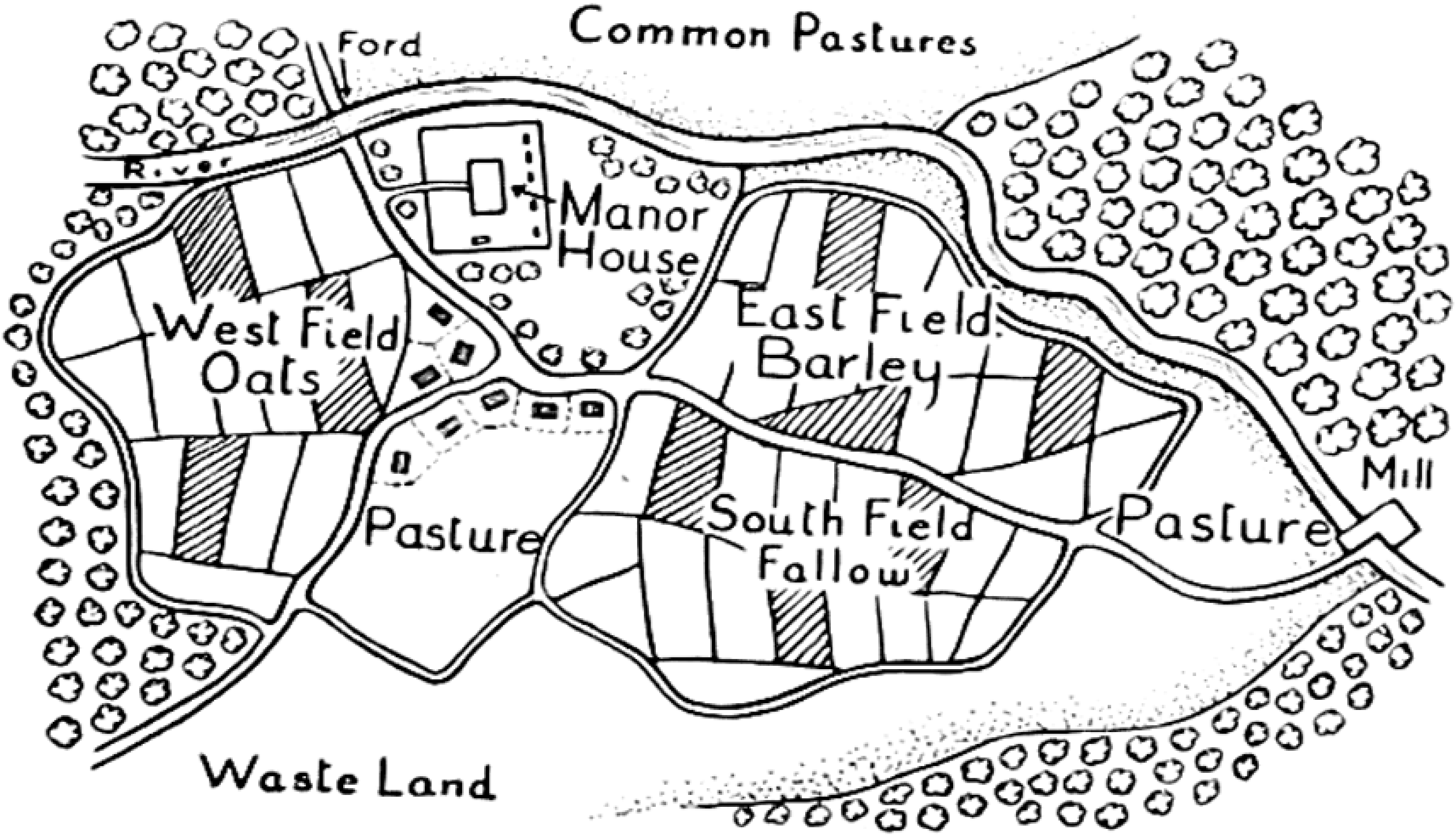
huts where each man could store his share of the crops and where he sheltered his milking ewes and cows, and his plough.

Most of the men in the village spent all their time working on this tremendous farm; some of them were village craftsmen as well. There had to be a thatcher, a blacksmith, and a carpenter to see to the buildings and ploughs, and there was also a beekeeper. The beekeeper was very important in those days because, of course, sugar was not imported from abroad and no sugar-beet was grown, so that honey was the only sweet food to be had and bees were kept in very large numbers. During most of the year the women were 'spinsters'—that is to say, they spun the wool into yarn and then made up all the clothes their families needed. They must have been very busy indeed as they had to prepare all the food as well; but in times of harvest they left their cooking and spinning and weaving, and went out into the fields with their men. Can you imagine several hundred people at work in the corn—some cutting with sickles, others binding up the sheaves, and the rest setting up stooks? That is the kind of thing that was necessary because the fields were very big indeed and quite unlike the small fields we have to-day. Many of them were some hundreds of acres in area! As you know, there are not many fields of more than twenty acres to-day. Can you picture such a big field of wheat or barley or rye? It would look like a sea of corn! No wonder all the villagers had to turn out to harvest it; but, of course, such a large number of helpers made short work of the job and the crop was got in as quickly as a binder can do it to-day.

THE THREE-FIELD SYSTEM

Most of these tremendous 'village farms' had three of the large fields you have just read about, and in addition there was an equally large meadow from which each of the village farmers took his share of hay. When this meadow was used for grazing, all the cattle of the village were let into it; and in some of the bigger villages there would be as many as five hundred beasts or more grazing at one time! Some of them were oxen used for ploughing, but most of them were the smaller cattle that were kept for meat and milk. Perhaps on grazing days this enormous pasture looked rather like a ranching scene such as we might find to-day in some parts of America or Australia. While they were grazing, these cattle were watched over by a chosen herdsman who drove them back to the village at night, so that each farmer could confine his beasts in his own yard. What a job it must have been sorting them out and getting them to their rightful owners! The village must have looked and sounded like a fairground each evening, and in wet weather the street must have become a mud-hole!—there was no concrete in those days! As you know, many of the beasts had to be killed in the autumn each year because there was not enough winter *keep* for all of them, so that the herdsman's job was easier in the winter months.

Did these farmers of bygone days use any kind of rotation for cropping their land? In order to answer this question you will have to remind yourself of one of the main reasons for changing the order of cropping on farm fields. You will remember that the growing of corn crops allows the annual weeds to seed freely, and as these farmers of Saxon and Norman and medieval times grew little but corn, they had to have some sort of rotation in order to clean the weeds out of each great field in turn. In order to do so they left one of the fields as a bare fallow every year—it was ploughed in the spring and the furrow clods were left to dry in the hot summer sun. In this way they were thoroughly baked and many of the weeds were killed. Then for two years this field carried corn before its turn came round for fallowing once again. You will see from this that two of the fields grew corn each year, and the third field had no crop on it at all. The usual corn crops were autumn-sown wheat, or rye, on one of the fields, and spring-sown oats or barley or beans on the other. You should try to



The ancient village farms of Britain grew little but corn. The shaded strips show the scattered holdings of one villager.

imagine the picture you would see if you could stand in one of those ancient village streets near to harvest time.

Perhaps on one side of the narrow road would be the huge fallow field lying baked and dry in the sunshine; on the other side would be the two fields of standing grain crops, maybe sixteen hundred to two thousand acres of waving corn! No hedges round the great fields; and not a tree to be seen, except at the fringe of the farmland where the forest began, and where the swineherds took their pigs to fill themselves with acorns and beech-mast, or to root in the earth for food. Truly you would think yourself to be in a foreign land; and yet the very piece of country where you now live and which surrounds your school may have looked like that in times gone by. It sounds almost like a fairy tale, but we must remind ourselves that this is what most of England did look like for more than a thousand years! From before the time of Alfred the Great, on to the days of Hereward the Wake and William the Conqueror, through the years when the Wars of the Roses were fought, and during the reign of Queen Elizabeth when William Shakespeare was writing his famous plays, this was the familiar farming scene in the English countryside. Can you imagine the dreadful famine that would follow a bad year? There was little or nothing to be got from abroad, and there were neither tinned foods nor potatoes to be had. If the grain crops failed, as they sometimes did, the people of the village went hungry. They had to produce all their own food, and if the weather brought famine there was little they could do about it. Here is a short description written in the Middle Ages by a poet named William Langland, who lived in the reign of Edward III (1327–1377):

The Peasant's Fare

'I have no penny,' quoth Piers, 'pullets for to buy,
Nor have I any geese or pigs, only two fresh cheeses,
A few curds and cream and an oaten cake,
And two loaves made with beans and bran for my little ones.
And yet I say, by my soul, I have no salt bacon,
Nor any big eggs, my goodness, to make bacon and eggs.
But I have some parsley and leeks and many cabbages,
And even a cow and a calf and a cart-mare
To draw the manure to the field in the dry weather.
And this is all I have for my family till Lammastide,[1]
By then, I hope to have the harvest in my croft
And we shall be able to have the sort of dinners I like.'

Read through this again, and notice that all the foods mentioned were things that the peasant could produce on the land he farmed. If you had been the son or daughter of this peasant farmer, you too would have looked forward eagerly to the coming of harvest—and a change in your diet. Not only did the autumn bring the new supplies of corn and beans and peas—this was also the time of the year when the pigs and cows and sheep were killed and the peasants had their fresh supplies of bacon and pork and other meat.

THE OPEN-FIELD STRIPS

Nowadays we speak of that old system of farming as the OPEN-FIELD SYSTEM because the three big arable fields were not surrounded by hedges. These fields were split up into long strips usually about twenty yards or so wide and from one to two acres in area. Each of the farmers in the village was responsible for several such strips on each field, so that altogether he had from fifteen to thirty strips scattered about the ploughland. This collection of strips was his farm! A field of modern allotments is divided out between the allotment holders in much the same way, and one man may be the owner of several patches of garden scattered about the field. Try to imagine such a field on a very much bigger scale and you will have a good picture of how the open-field system worked. Of course, each man had to follow the same rotation as every one else, and he was not free to choose the crops he grew on his many strips.

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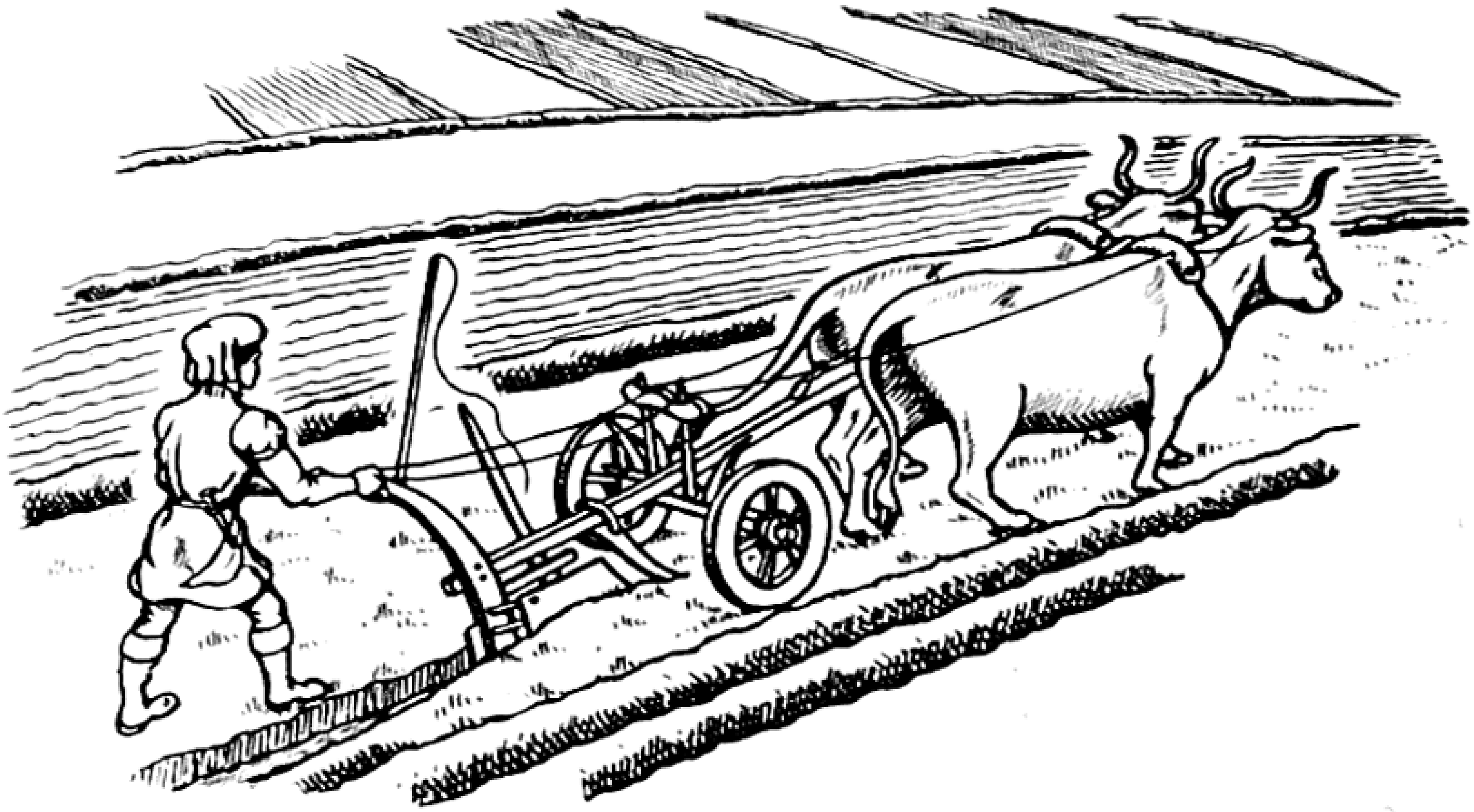
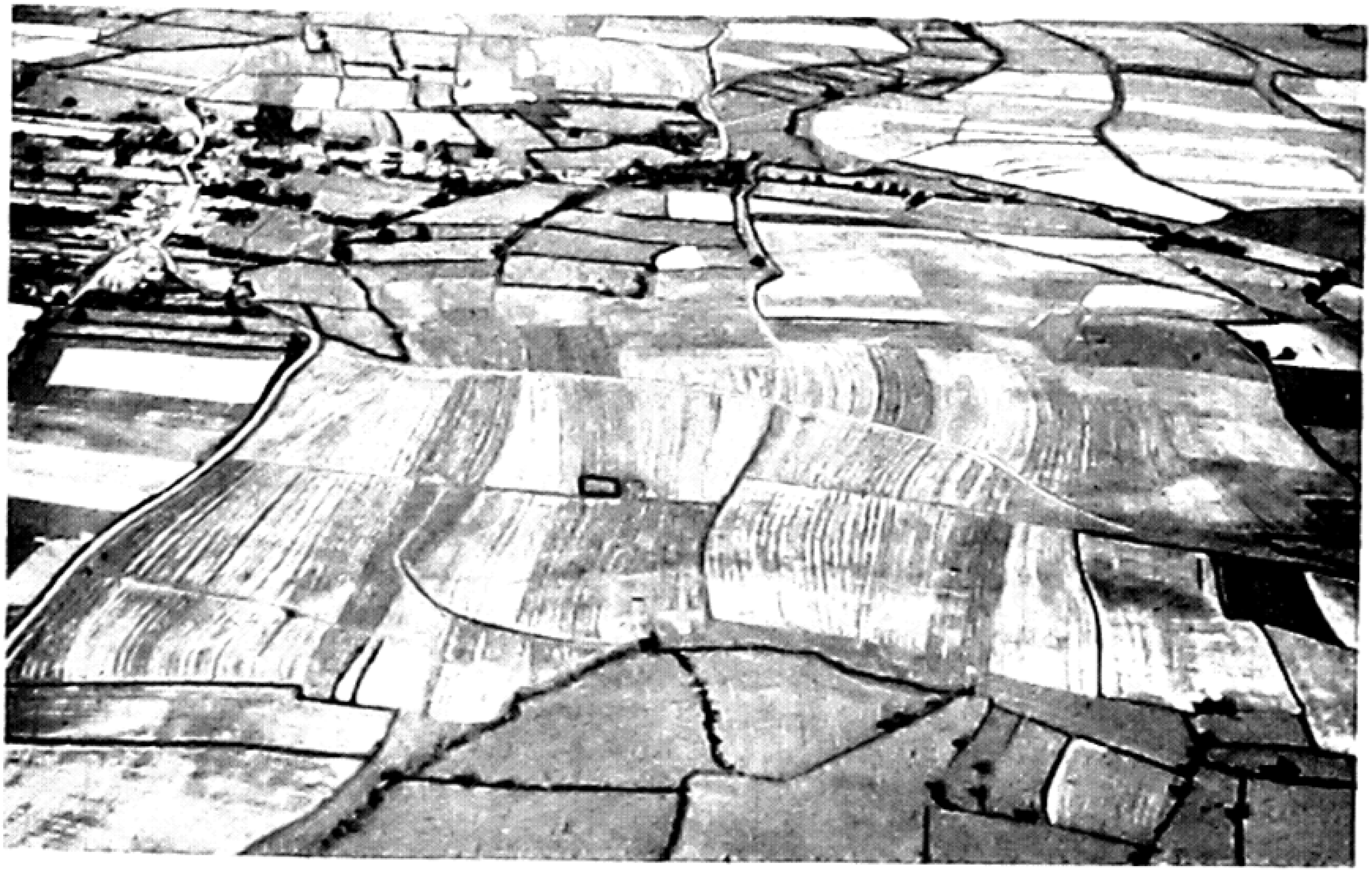
[1] Lammastide was the time round about Lammas, which was on 1st August. It was the day of harvest thanksgiving in the Middle Ages. Loaves of bread were taken to a special mass in church and songs of praise and thanksgiving were sung. Lammas really means *Loaf-mass*. After the alteration of the calendar in 1750, 1st August became 12th August, which is the modern date of Lammas.



Here is a medieval peasant at work on one of his strips. Two oxen were enough on sandy soil, but long teams of eight or more animals were needed to pull the primitive plough through heavy clay land.

After all the hay and corn had been cut in the autumn and carted to the village crofts, the whole of the land—both meadow and stubble—was thrown open for common pasture and each farmer's beasts could graze any part of the land. We rarely turn cattle or sheep on to the stubble nowadays because we have plenty of good pastures; but in those days every bit of grazing had to be used and the stubble weeds provided valuable food for the stock. After the harvest all the village farmers got busy on the field that had been lying fallow during the summer. They set about making a seed-bed and sowing the winter



At Laxton in Lincolnshire they still use the open-field system. In this aerial view you can see the village and one of the huge fields. Notice the strips. The surrounding fields are now enclosed.

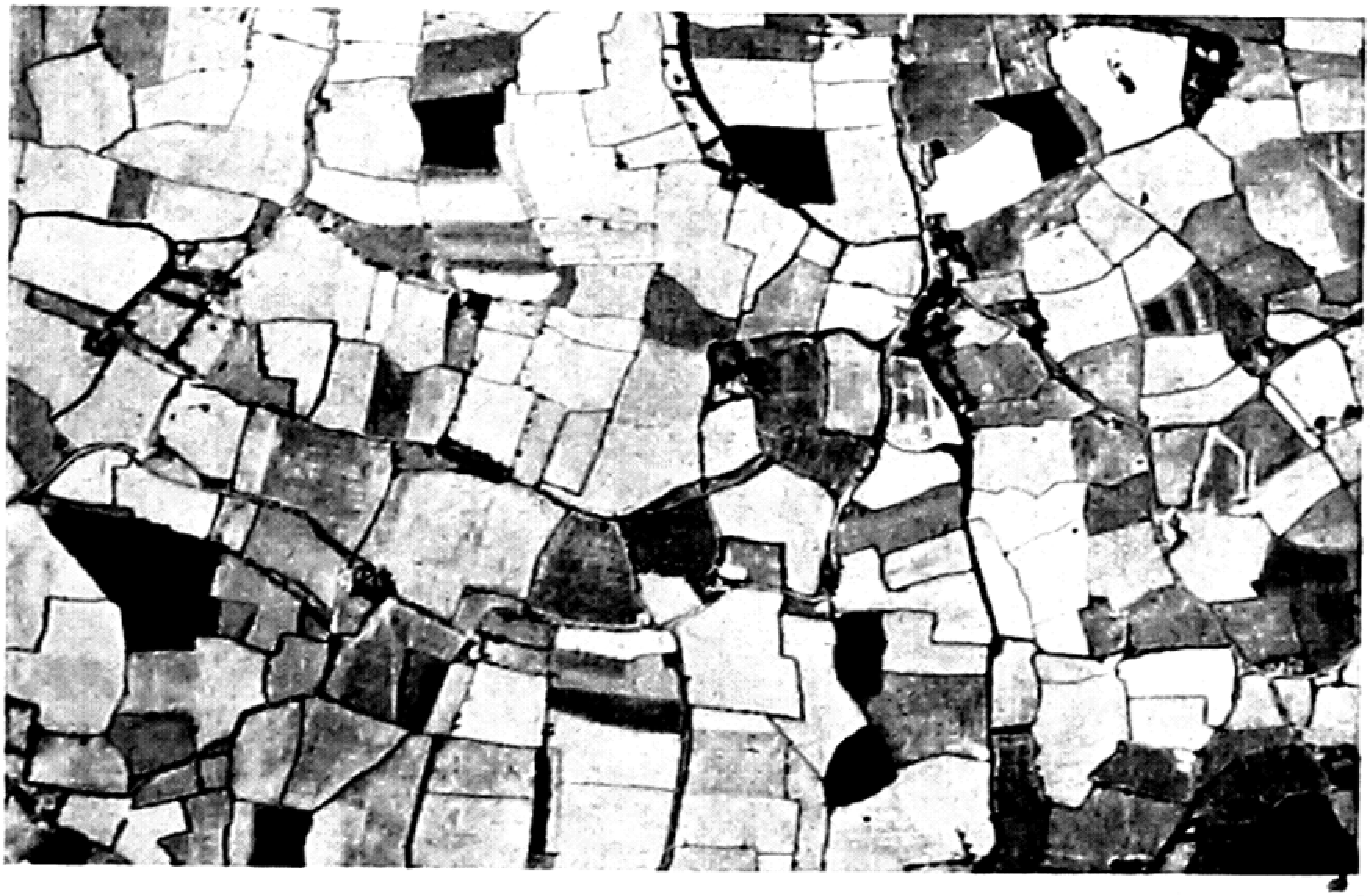
wheat or rye. The grazing livestock had to be kept off this field, of course, and so it was enclosed by portable hurdles.

THE NEED FOR HEDGES

Can you guess why it would be almost impossible to grow crops like turnips or clover on these open fields? As you know, turnips are harvested long after corn, so that any farmer who grew turnips on his strips would have had them eaten off by the village cows and sheep when they were loosed into the stubble after harvest. Clover would have met the same fate; so that when—in the eighteenth century—

Hedges became necessary when farmers began to grow turnips on a big scale. Is the horse treading on these turnips? What implement is he pulling?

turnips and clover were introduced on a big scale, it was essential to put up hedges on the farmlands to control the grazing stock and keep them away from the new crops. There were many other important reasons for the use of hedges and smaller enclosed fields, but this was one of the main ones. When the turnip began to come 'into its own' as an important crop, it helped to sound the death knell of a system of farming that had been in use in this country for more than a thousand years! When next you are helping in the turnip field you should think not only of the use to which the turnips will be put, but also



This picture was taken from an aeroplane 10,000 feet high. Notice the patchwork pattern of enclosed fields. Find the village and some scattered farmsteads. The dark patches are woods. Can you see any roads?

of the important milestone they once were in the history of British farming.

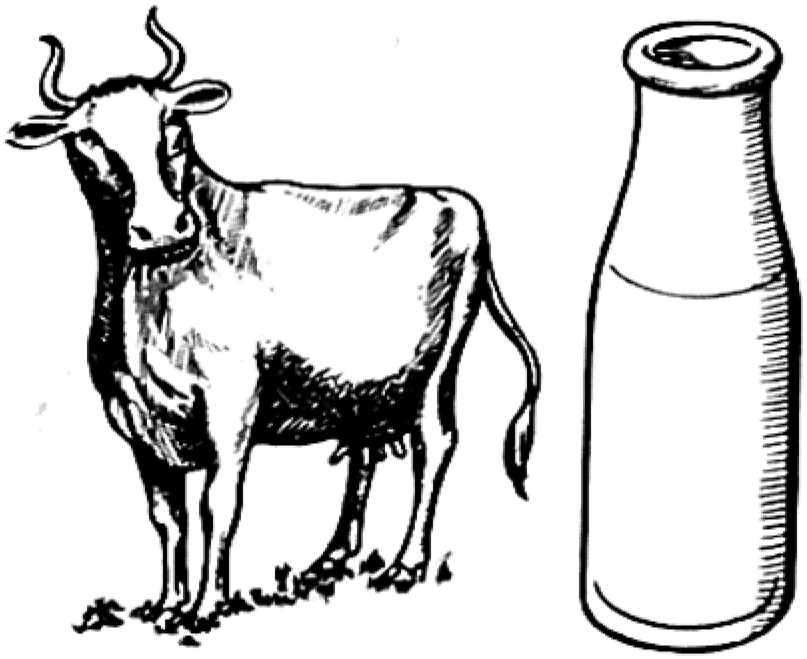
And remember, too, that turnips were the first crops to be grown in wide rows. Nowadays the farmer grows many other 'row' crops in addition to turnips: mangolds, sugar-beet, horse beans, kale, potatoes, and so on. Very often the farmer calls these his 'cleaning' crops. Can you think why? Remember his constant battle against weeds. Crops that are grown in widely spaced rows enable cleaning tackle (hoes and scuffles) to be taken on to the land long after the turnips and so on have begun to grow. In this way the young weeds can be hoed out of the soil and killed. It is the hoe or the scuffle that does the cleaning, you see, not the crop itself. Later on in the season, however, the row crops themselves do help to keep the weeds in check. They make such a dense mass of foliage that very few weeds can grow underneath them—for want of light. Since no row crops were grown in the days of the open-field system, the only way of cleaning the land was to let each great field lie fallow once in every three years. The arrival of the turnip made this wasteful fallow unnecessary.

The old system, which had been brought to Britain by the Angles and the Saxons, did, of course, have many advantages at the time. Under that system the people of the country could feed and clothe themselves without having to buy from abroad. But this meant that almost every one had to be a land-worker, and you should bear in mind that your own ancestors were almost certainly farmers. At the time of the Norman Conquest there were about one and a half million people in England, but even when the population had increased to ten million after the Middle Ages, the open-field system still provided enough food and clothing for every one. As the population continued to grow, however, better systems had to be found in order that there should be more food produced, not only in the summer but more especially in the winter. And the real improvements in farming began in the eighteenth century, when the growing of turnips and clover for winter cattle food became common. The smaller fields—enclosed by hedges—enabled this to be done, and as each farmer had his own fields grouped round his own farm buildings he

Here are some fine modern sheep in North Devon. Why did the enclosure of fields by hedges make it possible to improve our breeds of livestock?

was able to pay more attention not only to his soil and crops, but also to his animals—cows, sheep, and horses —as well.

You will remember from your studies last year that farmers like Robert Bakewell began to improve the breeds of cattle and sheep by careful selection of the breeding stock. These improvements could not have been started under the open-field system because the farmer did not have enough control over his own beasts—they had to run with the village herd and flock. This made the mating of selected cows and bulls impossible. When the *self-contained* farms—with the small enclosed fields—came along, enterprising farmers had a much better chance to carry out their own ideas; and because they were now their own masters they were more enthusiastic and progressive. Modern farming is the result of their work, and it is to them that we owe, among many other things, our supplies of fresh meat and milk in the winter. If we tried to farm on the open-field system to-day we should most surely starve. Although we have to buy great quantities of food from other countries, we do need to produce a very great deal of our food on our own farms, and that old system would certainly bring famine if we were to use it nowadays.



Our modern dairy cows give much more milk than their ancestors!

(This ancient method of farming in one large *community* has given to us some of our land measures. It was found that the team of bullocks or oxen had to be rested after pulling the plough for 220 yards or thereabouts, and this distance was called a *furlong* (meaning furrow-long). A piece of land that was 220 yards long and 22 yards wide was called an acre, and if you multiply 220 yards by 22 yards you will see that an acre contains 4,840 square yards.)

THINGS TO DO

(1) Imagine yourself to be a peasant boy or girl in the time of King Edward III. Write a story of a day in your life. Mention the time of the year, the house you lived in, the clothes you wore, your meals, what you had to do (there was no school in the farm village!), and what you saw. Make it sound real.

(2) Write single sentences in answer to the following questions:

- (*a*) Who made the peasant family's clothing in the Middle Ages?
- (*b*) What material did the Anglo-Saxons use for their huts?
- (*c*) Why do you think people made *half*-timbered houses in Queen Elizabeth's time?
- (*d*) Where did the medieval peasant farmer have his home?
- (*e*) Why were bees necessary in bygone days?
- (*f*) How many big fields did the open-field farms have?
- (*g*) How did each farmer know where to plough and sow his seed?
- (*h*) What happened to the fields after harvest?
- (*i*) Why did the coming of the turnip make hedges necessary?
- (*j*) For about how long did the open-field system of farming last in this country?

(3) Can you *estimate* the acreage of a field fairly accurately? Visit your local farm and go to each of several fields in turn. Write down their names (if they don't have names, make some up), and alongside write down the acreage that you guess. Then ask the farmer and put down the true acreage. Write the results in your book.

(4) Write down in two columns a list of the foodstuffs and drinks you would have been able to have and a list of those you couldn't have had (e.g. tea) in the Middle Ages.

(5) Write a short paragraph entitled 'Farming and the Population of Britain.'

4

Our Modern Cows and what they Eat

Half the pedigree goes in at the mouth.

A shelter is as good as a feed.

OLD COUNTRY SAYINGS.

Because half a dozen grasshoppers under a fern make the field ring with their . . . chink, whilst thousands of great cattle, reposed beneath the shadow of the British Oak, chew the cud and are silent, pray do not imagine that those who make the noise are the only inhabitants of the field. EDMUND BURKE (1728–97).

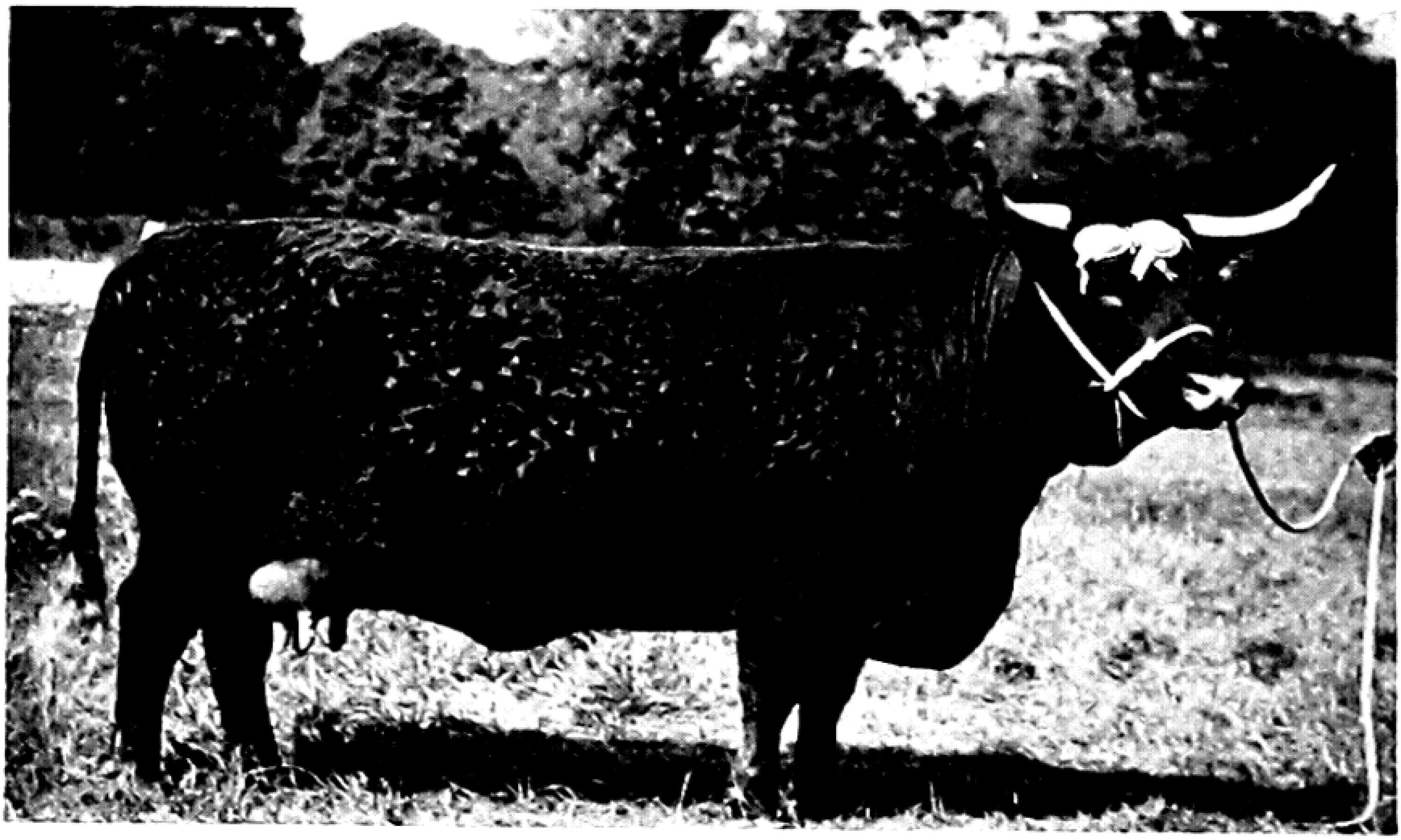
YOU have learnt that the big change over from open-field farming to the smaller enclosed fields was necessary because the good farmers wanted to keep their cattle through the winter instead of killing off many of them in the autumn. In order to do this they had to grow root crops like the turnip, and 'seed' crops like red clover so that they would have plenty of winter food for their animals. And because the new system enabled the farmers to keep their cattle during the winter, it was at last possible for them to set about the job of improving their farm animals. They now had more cows and bulls from which to select their breeding stock. It took many years, of course, for the results to show themselves, but in time the size of the cattle increased and the dairy cows gave much more milk both in summer and in winter. In addition, it became possible to have fresh beef all the year round instead of in the summer months only. The results of all this effort are to be seen among the cattle we have in our fields to-day. There are many different *breeds*, most of which we have produced in this country, though others have come to us from abroad. Let us examine them more closely.

Some breeds of cattle—like the Aberdeen Angus you see here—are never milked by the farmer. Do you know why?

BEEF CATTLE AND DAIRY CATTLE

Have you ever seen black hornless cows like those in the picture? They belong to the Aberdeen Angus breed, and they are rather smaller than most other cattle. Their calves are quite tiny and make a pretty sight with their wrinkled noses, large bright eyes, and chocolate-coloured faces. These calves are allowed to suck their mother's milk for many months, and you will perhaps wonder why the farmer permits them to do this. The calves of most of the cows you know are taken away from their mothers so that the farmer can have the milk for sale. Why are the Aberdeen Angus calves not taken away also? The answer is that the Aberdeen Angus cow does not produce much milk at all—just enough for her calf and no more—so that she would be no use in a dairy herd. But her calves—especially the bull calves—are noted for the beef that they produce when they are older. Not only do they produce meat of high quality—there is also a lot of it because they get very fat when they are properly fed. They carry a lot of flesh, as the farmer puts it. The Aberdeen Angus bullocks are not the only sort that fatten up for beef in this way; there are other breeds of cattle also that are kept for meat rather than milk. We call them BEEF BREEDS. A farmer can keep cattle of this kind without having to milk them at all. You may well think that this is a good way of losing money! But you must remember that some farmers are too busy with crops like sugar-beet and barley and wheat to bother about milk. They are able to sell the fat bullocks, of course, when they are ready to be killed for beef. But rearing cattle for beef is not a very profitable business—certainly it is less profitable than keeping a dairy herd. There must be some other reason for keeping beef breeds. What is it?

Do you remember the importance of organic matter in the soil—and the need for farmyard manure? In order to make farmyard manure, both straw and dung are necessary; so that farmers whose land grows a good deal of corn very often keep beef cattle in order to turn the straw into manure. Years ago, in the middle of the nineteenth century, British farmers kept many more beef cattle than they do to-day because fat bullocks always 'fetched a good price,' but when the cheaper beef began to come to us from the big ranches in the Argentine, the price of good English beef had to come down and it was not possible to go on raising so much beef in this country. Nevertheless, we cannot do without cattle on the cornland farms because of the manure they make. Let us remember the old saying: 'No man can take out of his land more than he puts in.' Can you explain the meaning of this? Manure provides many plant foods, and it keeps the soil rich and 'in good heart.'

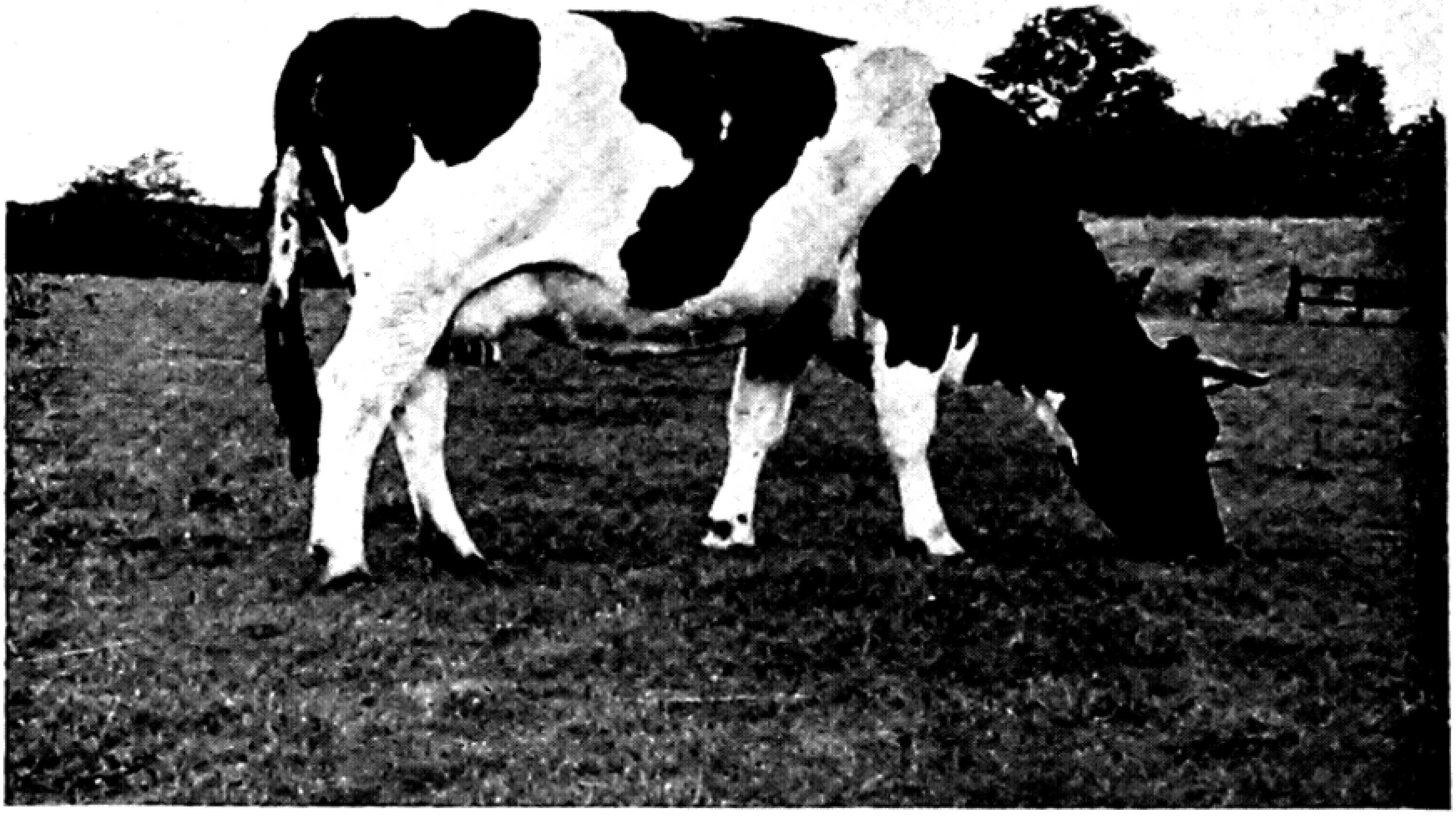


Notice the 'blocky' shape of this fine Devon cow.
Why is her udder so small?

There are many of these beef breeds, and you see two other examples in the illustrations. The dark-coloured one with a curly red coat is a *Devon* cow and the one with a white face is called a *Hereford.* Do you notice their short legs, deep shoulders, and fleshy thighs? They have a very 'thick-set' appearance, and certainly look as though they could carry plenty of good beef! If you compare them with the pictures of dairy cows you will see a big difference in shape. The Hereford is the most popular ranch beast in America, and if you see a picture of a western round-up on the films you will no doubt notice the white faces of most of the cattle. It is really a British breed, and we have a right to be proud of providing

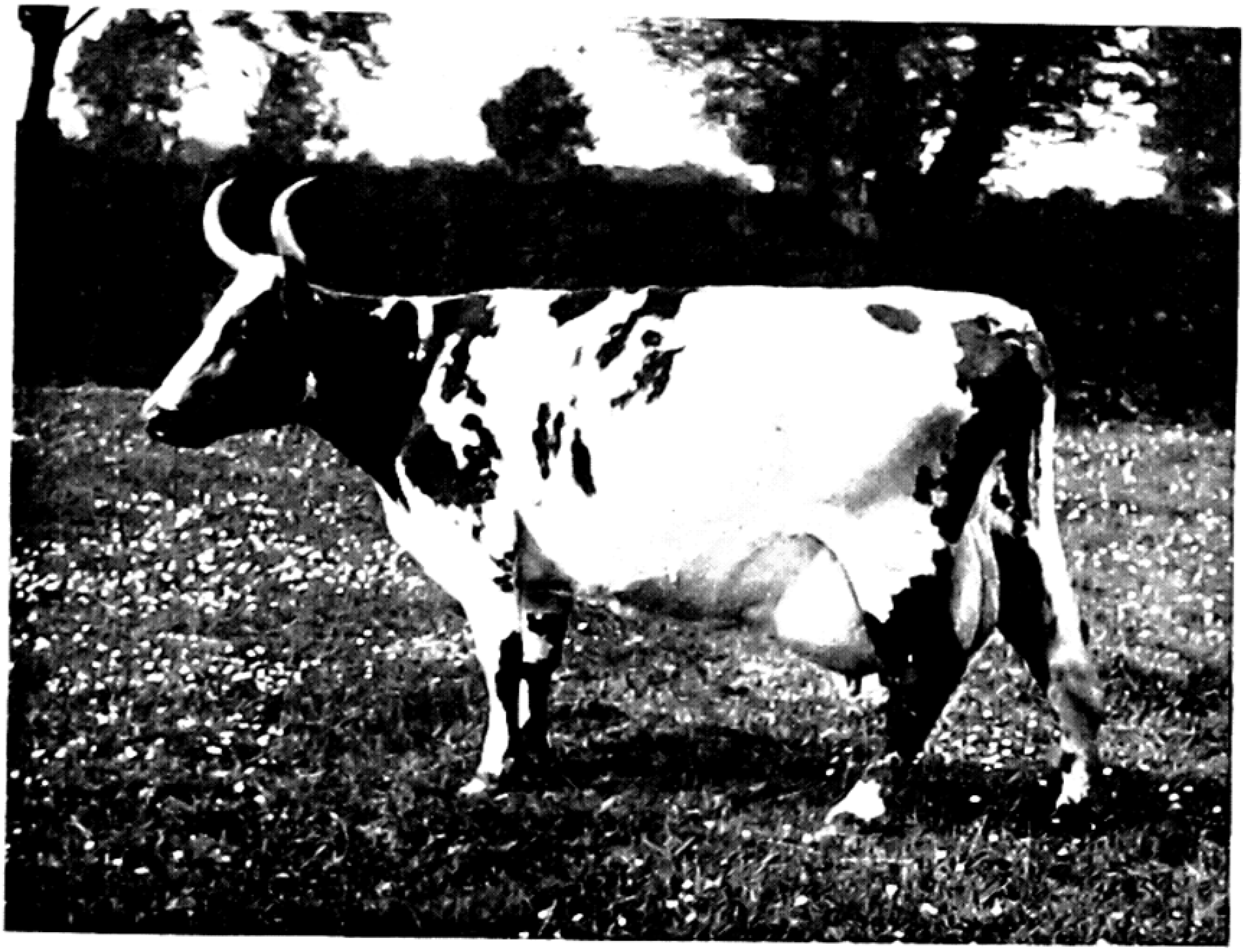
Here is another beef animal—a Hereford bull. Many of the big beef ranches of the world are stocked with Herefords.

the cattle that roam the great ranches of the world. Of course, the Hereford cattle to be found on these foreign ranches were not born in England—but their ancestors came from Britain. We say that the breed *originated* in this country. Even to-day many of our best bulls are sold to foreign ranch owners for breeding purposes.



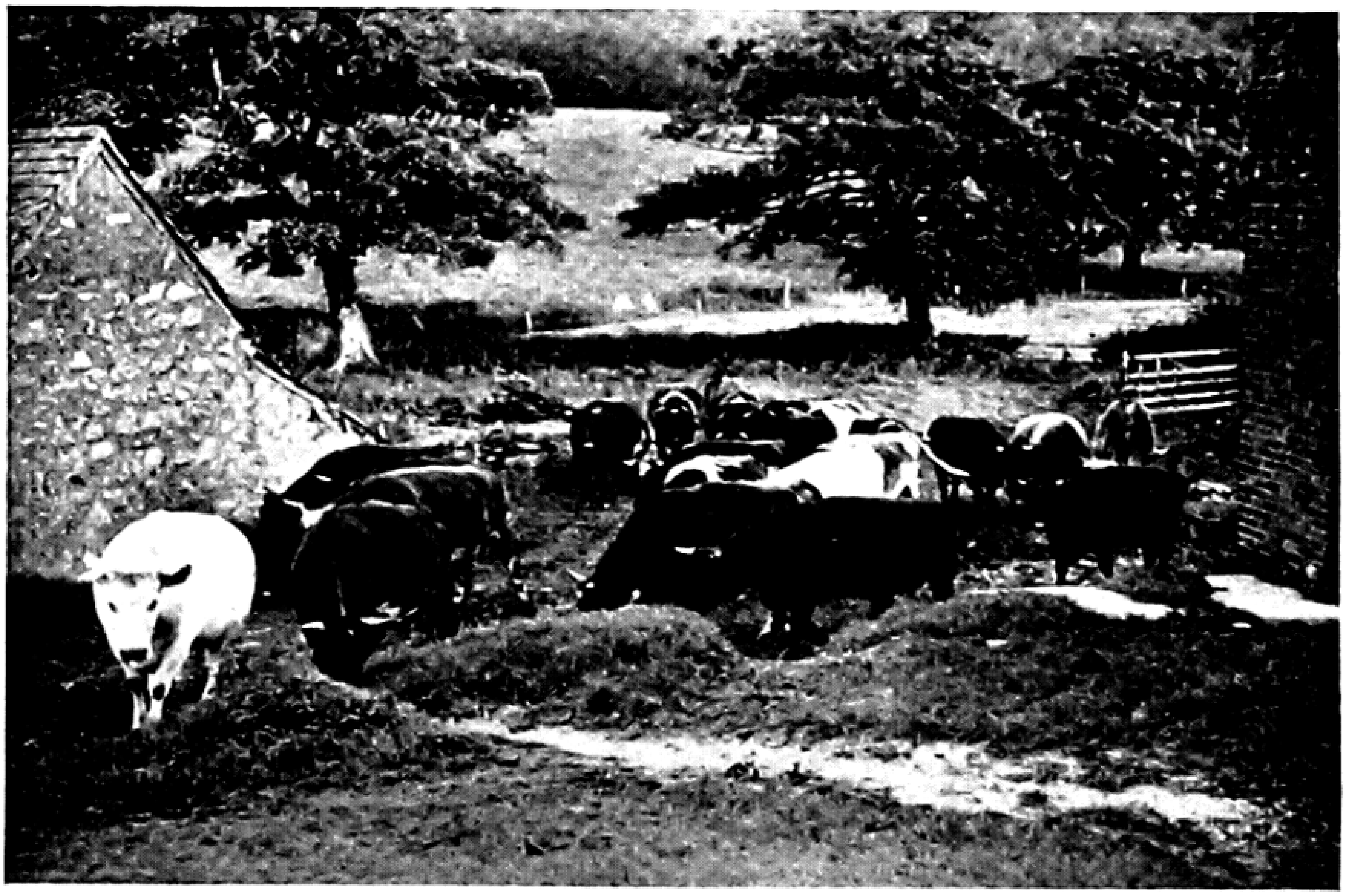
This British Friesian heifer is a dairy animal. She is not so 'deep' in the body as the cows of the beef breeds.

If you now look at the pictures of the dairy breeds you will notice many differences. They are not so 'thick-set' or heavy-looking at all as the beef cattle; they have longer legs, much more angular bodies, and carry less flesh. Do you notice how much bigger the udders are? You would expect a good milker to have a large udder. The black-and-white cow belongs to the Friesian breed which came to us from Holland in the last century. These cows give more milk than any other breed, and some of them have been known to give three thousand gallons between the birth of one calf and the next. Good dairy cows of this kind are able to give extraordinarily large quantities of milk when they are on 'top form,' as we say; indeed, such a cow may well yield from eighty to a hundred pints of



What does the size of this Ayrshire cow's udder tell you? Compare her with the Devon cow (page 56) and say how she differs in shape.

milk in a single day. Think of all that milk coming from one cow! It is enough to supply the day's milk ration for a school of about three hundred children. Such deep milking cows are, of course, exceptional, and two or three gallons a day is nearer to the average



Shorthorns are a dairy breed, though some farmers use them for beef as well. Some are red, some are white, and some are roan—here you see examples of all three colours.

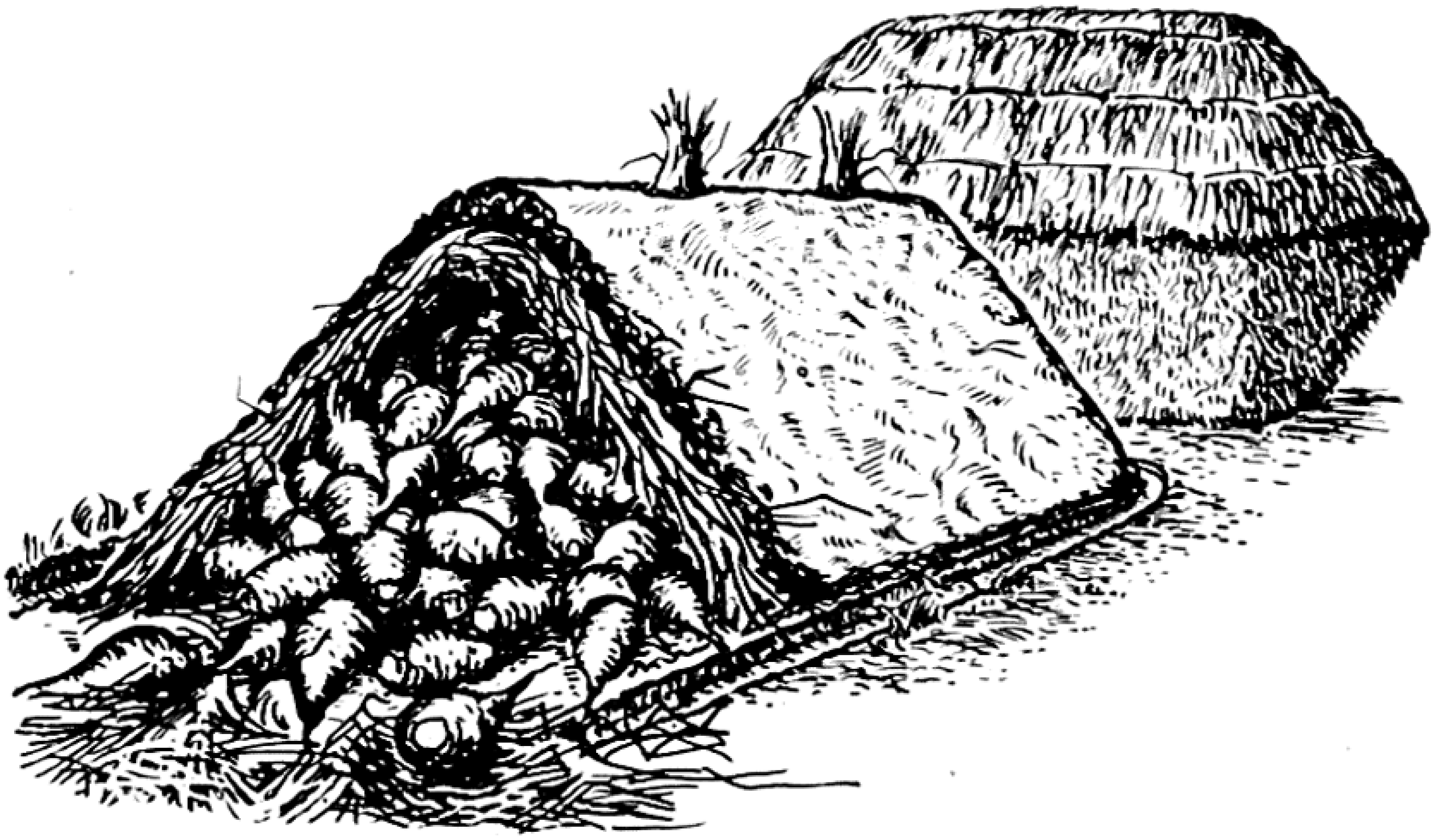
yield of British dairy cows. When you think that the cows kept in the Middle Ages probably gave no more than three or four pints a day during the spring and summer months—and much less in winter—you will realize the tremendous improvements that started when men like Robert Bakewell (1725–95) began to breed better cattle. The cow with rather long horns and pointed face (page 59) is an Ayrshire, and the herd coming to the farm buildings—some red, some white, and some roan—are all Shorthorns. All these dairy breeds—Friesians, Ayrshires, and Shorthorns—are quite common, and you should try to pick them out when you see herds of cattle in the country. Perhaps there are other kinds near your home. Try to find out what they are and add their names to your list. For the present it is enough for you to remember the six breeds shown in the pictures:

Beef Cattle	*Dairy Cattle*
Aberdeen Angus	Friesian
North Devon	Ayrshire
Hereford	Shorthorn

THE FOOD COWS EAT

In the lesson on breathing you learnt that even when you are sitting quite still, or lying asleep in bed, your breathing uses up some of the food that you have eaten. In this way you are kept warm, and energy is provided for your heart to keep on beating. This is true of any breathing animal, and even a full-grown cow that is not moving about or putting on flesh will need some food to keep her alive and warm. Even if she was quite 'dry' (i.e. not giving any milk) and spent all her time lying on a comfortable straw bed in the cow-house, she would still go on using up food with every breath she took. If she is outside in cold weather or if she is made to run about or walk long distances to and from the pasture field, she will use up more food still. Think how much more hungry you are yourself on a cold day or when you have been playing games or working in the garden.

Of course, fresh air and exercise improve the health, and it would never do to keep the cattle indoors all the time to save food; but the farmer knows quite well that the food his cows use up in order to keep them alive and well provides no milk or extra beef. In one sense it is a complete loss to him; but, of course, it is quite necessary for the cows to have it. This part of their food is called their MAINTENANCE RATION—meaning the ration that maintains them or keeps them going.

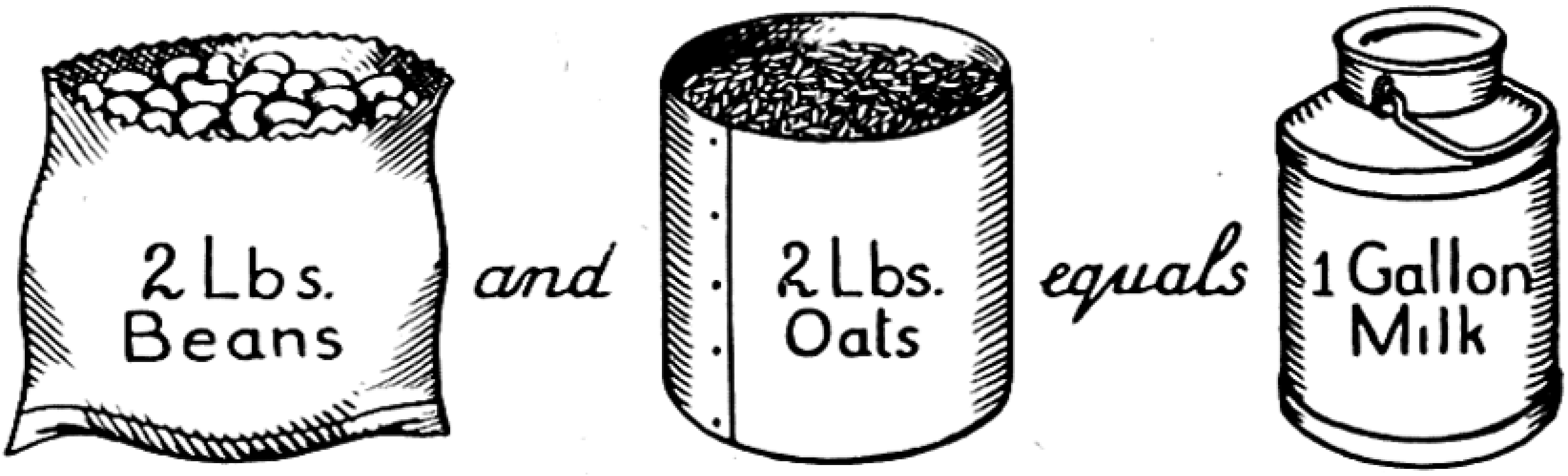


During the winter—when fresh grass is in short supply—cows eat great quantities of mangolds and hay.

How much food does a cow or a beef bullock that is being fattened need to maintain it in good health? Let us think of a whole herd and ask how much hay and mangolds they would need to keep them going through the winter. There are many different foods that could be used, but hay and mangolds would serve quite well. Thirty cows would use up about *one hundred tons* of mangolds and about *thirty tons* of hay from October to April just to keep them alive and well! Can you picture a clamp of mangolds or a stack of hay containing these amounts? If not you should ask your farmer friend to tell you the weights of roots and hay he has in his clamp and stacks—so that you can learn to realize what these figures mean in actual materials. You can imagine how glad he is when winter has gone and the cattle can go out to grass again, because they can easily get all their maintenance ration by eating fresh grass.

Now the farmer wishes his cattle to do more than keep in good health; they must produce something he can sell also! If they are beef cattle he wishes them to put on extra weight in the form of beef and fat, and if they are dairy cows, he wishes them to produce plenty of milk, and it is also necessary for the cows to produce calves from time to time. In order for them to do these things they must have extra food, because no cow can make milk or calves out of nothing; nor can a bullock make fat without eating more food than it needs just to keep alive and well. It is just the same with grown-up people; they only begin to get very fat if they eat more food than their bodies need, and when a mother is suckling her baby she needs extra food to make the milk that the baby drinks. All living things, plants as well as animals, use up food whenever they make new parts or create offspring.

The good farmer is well aware of this, and he takes care when he is feeding his cattle to give them that extra food. He calls it the PRODUCTION RATION. How much food is used by cows in order to make one gallon of milk? Of course, they are given a variety of foods because they like a change of diet just as we do ourselves, but let us suppose that the farmer is using oats and beans for the job. One cow requires, on the average, two pounds of oats and two pounds of beans to make one gallon of milk. Now each cow in a good herd may give three gallons of milk a day, so she would need six pounds of beans and six pounds of oats a day—in addition to her maintenance ration. A herd of thirty cows would need 180 pounds of oats and 180 pounds of beans. In order to last for the whole winter, the farmer would need to have over a hundred sacks of beans and nearly two hundred sacks of oats for his thirty milking cows, and in return they would give him about fifteen thousand gallons of milk between October and April—just at the time of the year when it is needed most.



All the cow's milk is made from food that she eats and water that she drinks.

Can you imagine all this food—the food for maintenance and the food for milk production—standing in the farmyard at the beginning of the winter—one very large stack of hay, and a big clamp of mangolds, together with about three hundred sacks of grain? The farmyard would be almost full of food, and it is strange to think that thirty cows can eat it all before the summer comes again! Not every farmer, of course, uses these particular foods. Instead of mangolds he may grow swedes, kale, sugar-beet tops, and so on; and he will probably use special *cattle cakes* for milk production in place of some of the oats and beans. But by one means or another he has to provide this winter food, and the important thing for you to remember is that one of two things will happen if the cows don't have enough food:

One of the dairy farmer's biggest tasks is to provide enough winter food for his herd.

(*a*) They will give less milk, or
(*b*) They will begin to lose weight and become ill.

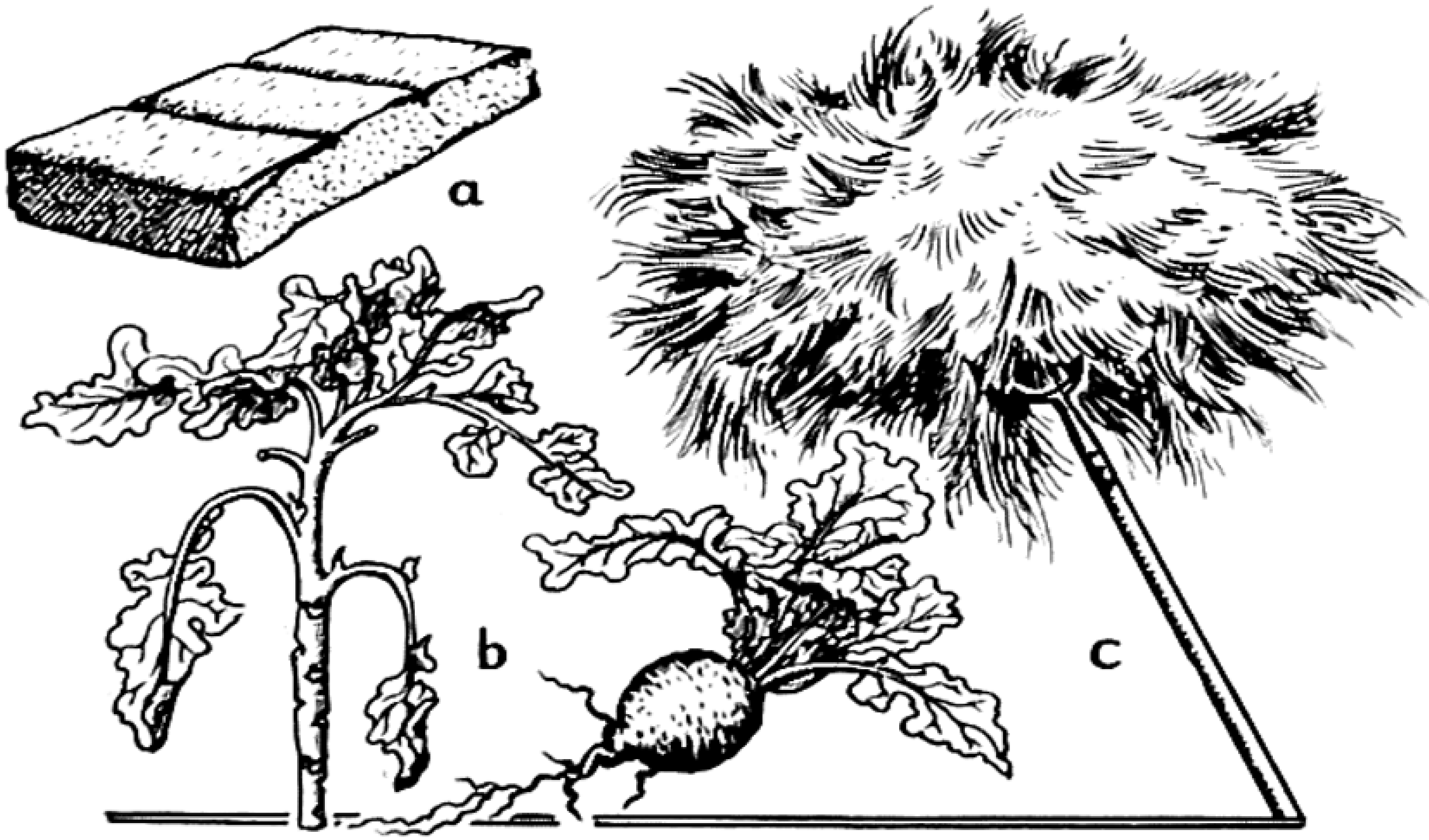
That, of course, is just what did happen in the days of the open-field system, and it was the shortage of winter food in those days that made it necessary to kill so many animals in the early autumn for making salt beef.

Even in the summertime, when the grass is rich and plentiful and the cattle spend both day and night in the fields, the dairy farmer has to go on giving his milking cows some extra food for producing milk. But not so much as in the winter because the grass provides all the maintenance part of the ration and also enough for about two gallons of milk from each cow every day. Those cows that give more than this amount—and most of them would—need to be given extra oats or beans or cattle cake. They are given this extra food at milking time.

It is important, also, to notice that a dairy cow drinks a good deal of water because, of course, all the water in her milk comes from what she drinks. An average cow needs about twelve gallons a day when she is 'in milk'! For this reason it is most important for dairy farms to have a good supply of clean water. Nowadays it is becoming more and more common for water to be piped into the cowshed so that the cow can have a good drink at milking time; and on many farms, clean water is piped into the fields as well.

HOW THE DAIRY HERD IS FED

When you go into the cowshed at milking time you should notice the way in which the cows are fed because, of course, there is a right and wrong way of doing most things—and the feeding of cattle has to be done in a very special way. As soon as the cows come in they are given their *concentrates*, as the bean meal or oat meal or cattle cakes are called. These things are the most tasty part of the ration and the cows eat them up greedily. They are called *concentrates* because they are very rich foods. The herd is then milked and no more food is given until after the milking is over. Can you reason out why? Remember that the farmer wants his milk to be sweet and clean, and if hay was being carried about the cowshed while the milking was going on, a good deal of dust would get into the pails and churns. Juicy or *succulent* foods like turnips or kale or *silage* (which is really pickled grass!) have a very strong smell that easily gets into the milk and gives it an unpleasant taste. For these reasons, the succulent foods are given



Such foods as these are often fed to cows at milking time. *a* is cattle cake; *b* is *succulent* food; *c* is hay. Can you state the order in which these things will be given to the cattle?

when all the milk has been taken into the dairy, and the hay is given last of all. When you have *your* meals the cake comes last, as a rule!—and you have to eat the less tasty things first! Cows, however, have their meals the other way round. But, as you see, there are very good reasons for this.

Here is an old saying, often heard in the country:

A cow little giveth
That hardly liveth.

'Hardly liveth' means that she lives a hard life because she doesn't get much to eat. If you learn this old saying by heart you will easily remember the importance of feeding cows properly.

THINGS TO DO

(1) Imagine you are in charge of a herd of dairy cows. Write a long letter to a friend in the city, telling him the story of a day in your life in the winter. Mention the breed of cows, the food you give them and all the jobs that have to be done throughout the day. Your letter should make him want to leave the city streets and join you for a day.

(2) Use single sentences to answer the following questions:
   - (*a*) What are beef cattle?
   - (*b*) What valuable material is made by cattle in addition to milk and beef?
   - (*c*) Why are beef breeds allowed to go on suckling their calves?
   - (*d*) What is the most common breed of cattle on the big ranches of the world?
   - (*e*) What is one good reason for not chasing cows about the fields?
   - (*f*) What does the farmer call the food that cows need in order to keep alive and well?

(*g*) What is the name given to the food that cattle turn into milk or beef?

(*h*) Why is it important for dairy cows to have plenty of water?

(*i*) Why does a farmer feed turnips or kale to his cows *after* milking is over?

(*j*) What would be the effect of letting cows eat hay during the milking time?

(3) Get pictures of five different breeds of cattle and fasten them neatly into your Country Book. Write the name of the breed underneath in each case, and say whether it is a beef or a dairy breed.

(4) Find out from your nearest farmer what winter foodstuffs he has grown for his cattle. Make a list of these and put down the quantities he has of each: e.g.

Clover hay . . . 70 tons

If he buys some foods in, make a list of these also.

(5) Make a list of the cattle foods that will be growing in his fields next summer and put down the number of acres he will use for each crop.

For your next lesson you will need a small jar or a tumbler, some sour fruit like a lemon or a stick of rhubarb, and a liquid called B.D.H. Soil Indicator[1] that you can buy at the chemist's. Get these things ready.

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[1] Note to the teacher: B.D.H. Soil Indicator can be had from the British Drug Houses Ltd., Poole, Dorset. The cost is about 2*s.* 6*d.* a bottle.

5

Acid or Alkaline?

> The purest treasure mortal times afford
> Is spotless reputation; that away,
> Men are but gilded loam or painted clay.
> *King Richard II* (SHAKESPEARE).

MANY of the things we eat—especially some fruits—have a sour taste. We say they have a *tart* flavour. Some are much more tart than others, and an unripe lemon is so sour to the taste that it probably makes you wrinkle your face even at the very thought of eating it. If you wish to make your mouth 'water' just think of eating a sour lemon! Unripe apples and gooseberries also are quite sour, and no fruit is really sweet until it is thoroughly ripe. Other parts of plants can be sour, however, and some children will eat the leaves of sheep's sorrel—or 'sour dock,' as it is called in some country places—when they feel hot and thirsty. The fleshy stems of rhubarb have the same effect and, indeed, we call these 'sticks' of rhubarb a fruit because of their tart flavour.

Why do lemons and the leaves of sorrel taste so sour?

Rhubarb is not, of course, a true fruit because it doesn't come from a flower.

What causes this sourness in fruits? Is it due to the presence in the fruit of a sour substance? Whenever you eat something that tastes sweet you suspect the presence of sugar. Cakes taste sweet when they contain sugar, so does jam. In the same way, sour fruits taste sour because they contain a substance that we call an ACID. There are many kinds of acid—the one in apples is not the same as the one in lemons. But whatever differences there may be between them, *acids always taste sour.* These acids do not get into the plant from the soil or the air, of course, but are made by the plant itself. First of all, sugar is made in the leaves and other green parts, and then, in order to make its fruit taste sour so that insects will not eat it, the plant changes some of this sugar into an acid. You must remember that every bit of a plant comes mainly from the sugar that is made in the leaves—even the wood in the trunk of a great tree! Without first making sugar the tree could not even start to make new timber! So it is with the acids in fruit; they are made from sugar by the plant itself.

You will require these things for the 'conjuring trick' in Experiment 1.

Experiment 1. A Simple Test for Weak Acids. A small jar will do for this experiment, but a tumbler or a wineglass is better because you can see more easily what is going on. Half fill your glass with tap water, and then put in four or five drops of soil indicator. Shake it round carefully so as to mix the liquids together. Your water will now be coloured *a beautiful blue—and this means there is no acid there at all.*[1]

Now take a slice of lemon, or a green gooseberry, or a stick of rhubarb, and squeeze a few drops of juice into the coloured water. What happens? The blue colour vanishes and the water becomes yellow, or even pink. This is rather like a conjuring trick!—it is also a test for your acid. *Whenever the coloured water turns yellow or pink an acid is present.*

You should repeat the experiment, using vinegar. Is vinegar a real acid?

Experiment 2. A Test to see whether Carbon Dioxide is an Acid. In this experiment we wish to find out whether the carbon dioxide of our breath causes a similar change of colour. Start off as you did before with some coloured tap water. Now, using a tube of some sort (a glass tube is best because you can see whether it is quite clean and dry), blow some bubbles of your breath through the blue water. The colour very soon changes to yellow. This means that some acid has got into the water. It came from the carbon dioxide in your breath. As soon as this carbon dioxide gets into the water it changes into an acid called *carbonic acid.*

In addition to the weak acids that you have been examining there are some strong acids. You should know about these because they are dangerous; they are not only poisonous, but they will damage your skin or clothing, and you should on no account touch them without your teacher's permission. The three most common ones are nitric acid, sulphuric acid, and hydrochloric acid. These acids are so strong that between them they will dissolve copper, zinc, and marble! You have to use hydrochloric acid in some of your experiments, but only when it is *dilute*, that is to say when a good deal of water has been added to it.

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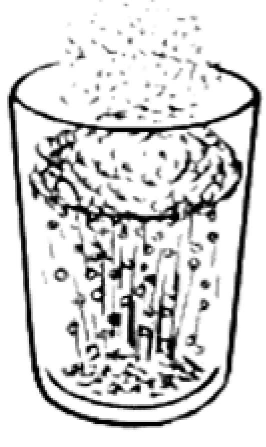
[1] Most tap water turns the indicator blue, but if the water from your tap is very pure indeed, it may be necessary to add *one or two* drops of lime water to the jarful of tap water in order to get the blue colour.

ARE THERE ANY SUBSTANCES THAT 'KILL' ACIDS?

If you want to make yourself a very pleasant 'fizzy' drink, you should squeeze the juice of a lemon into half a tumbler of sweetened water. Now put in about a saltspoonful of the bicarbonate of soda that your mother uses when she is baking. The drink froths up, and you will notice that the sourness of the lemon has gone also. Does this mean that the acid has been changed into something else? Let us try another experiment.


How can you make a 'fizzy' drink with lemon juice?

Experiment 3. To see whether Bicarbonate of Soda 'kills' the Acid of Fruit. Take your jar or wineglass again and half fill it with tap water. Now add four or five drops of soil indicator to make your blue liquid.

Squeeze in several drops of sour fruit juice and you will see that the colour changes to yellow or pink as before. Remember that this change of colour indicates the presence of an acid. If we can kill this acid in some way, the colour *should* go back to blue. Let us try. Put some bicarbonate of soda on the edge of a small strip of paper and shake a little of it into the glass. What happens? The return of the blue colour shows that *you have 'killed' the acid with the bicarbonate of soda.*

Do this experiment again, but instead of using fruit juice use a drop or two of vinegar. When you have got the yellow colour, add a few drops of *weak* ammonia this time. Does the ammonia 'kill' the vinegar in the same way? You will find that it does.

Now try the experiment again, using sour fruit juice and lime-water!

Your experiments have shown you that there are substances that change acids in some way. Bicarbonate of soda is one, ammonia is another, and lime-water is yet another. A substance that counteracts or *neutralizes* acids in this way is called an ALKALI. You may think that because sugar is able to sweeten sour fruits that it also is an alkali; but this is not so. The sour acid of the fruit is still there even after sugar has been added, but the sweetness of the sugar makes the sourness less noticeable. Sometimes, when sugar is very scarce, cooks put a little bicarbonate of soda into sour fruit before making puddings in order to destroy the acid. But such things taste very 'flat' and uninteresting because the sharp flavour of the acid has been completely destroyed. It is far better to use sugar if you can, as you then have the acid flavour and the sweetness as well. 'Killing' or neutralizing the acid with bicarbonate of soda takes the sourness away, but it doesn't make the cakes and puddings sweet.

LIMESTONE AND RAINFALL

You know that farmers and gardeners often put 'lime' on their soil. There are many different kinds of lime, but they all come from rocks in the first place—either from limestone quarries or chalk quarries. Sometimes the fresh rock is changed by burning or grinding, so that the material used by the farmer may not look a bit like a rock—indeed, it is often just a white powder. But the lime is still in it, and all these different forms of lime have the same effect on the soil. Let us try to find out what this effect is.

Experiment 4. To Test the Effect of Lime on Acids. Take your jar or tumbler and half fill it with water. Now put in a few drops of soil indicator and about half a teaspoonful of *dilute* hydrochloric acid. Stir it up and the liquid will have a yellow or pink appearance, showing the presence of the acid. You are now ready to test the effect of some lime. You can use any kind you like so long as it is in powder form. Powdered chalk will do quite well. (Not blackboard 'chalk,' as this isn't real chalk at all!) Put a teaspoonful of this powdered lime into the tumbler and stir it up. What happens? You will see that the colour changes to green or blue. Your lime has neutralized or 'killed' the acid.

This experiment proves to you that lime is an alkaline substance. Of course, your single teaspoonful of powdered lime would not go on neutralizing acid in large quantities. Can you think why? It is because the lime itself gets used up by the acid. The more acid you have, the more lime will be needed to 'kill' it, because each changes the other. The acid and the lime join together to form a new substance which *dissolves* in the water.

If you go to some part of England where there are limestone rocks you will find as a rule that there are many big caves in the district. There are good examples at Cheddar in Somerset, or at Castleton in Derbyshire, or at Ingleton in Yorkshire. These caves in the limestone have not always been there; a very long time ago—millions of years ago!—there was solid limestone rock where the caves now are. How then were the caves formed? Do you remember what you discovered about carbon dioxide in Experiment 2? You found that when it dissolved in water it produced an acid called carbonic acid. As you learnt in Chapter 1, there is not a large proportion of carbon dioxide in the atmosphere, but there is always some; so that, when it is raining, the raindrops dissolve a small quantity of carbon dioxide, and the rain that falls on the ground always has a tiny quantity of carbonic acid in it. Not very much, of course—indeed the quantity is so tiny that you would not be able to show its presence even with your soil indicator—but it is there nevertheless. Now try to think what happens as this rain-water drains through the limestone rocks. What will happen to the limestone? It will neutralize the acid in the rain-water and at the same time it will be slowly dissolved away itself—and be carried off in the drainage water. Exactly the same thing happened when you did Experiment 4 with the acid and chalk! This is the way in which the huge caves at Cheddar and Castleton and Ingleton have been formed. It took a long time because the carbonic acid in rain-water is so very weak—and, indeed, the *process* is still going on, but the changes are so slow that no difference in the size of the caves can be seen even in a whole lifetime.

LIME AND SOIL

You will now understand why farmers and gardeners need to put lime on their land. Every time it rains, a little more carbonic acid gets into the soil and we say that it becomes 'sour' or acid. Many plants will grow quite well in soil that is slightly acid—think of trees and heather and moorland plants. Nobody puts lime on to the soil in which these plants grow; but most of the crops that the farmer grows and the vegetables we grow on the garden do much better in soil that is not acid at all. For this reason, land on which farm and garden crops are grown has to be 'limed' from time to time. This is not the only reason for

This farmer is scattering lime over one of his fields. What two important effects does lime have on soil?

keeping fields and gardens 'sweet' with lime, but it is of great importance and you should remember it. There are some kinds of soil in England that already contain lime and do not need any extra, but they are not common, so that most farmers need to dress their ground with lime every four or five years. The Government knows how important it is to do this, and they will pay half the cost of all the lime a farmer uses! You are now going to test some soils to see whether they are sour or sweet.

Experiment 5. Testing Soil for Sourness. You will need a handful of three different sorts of soil:

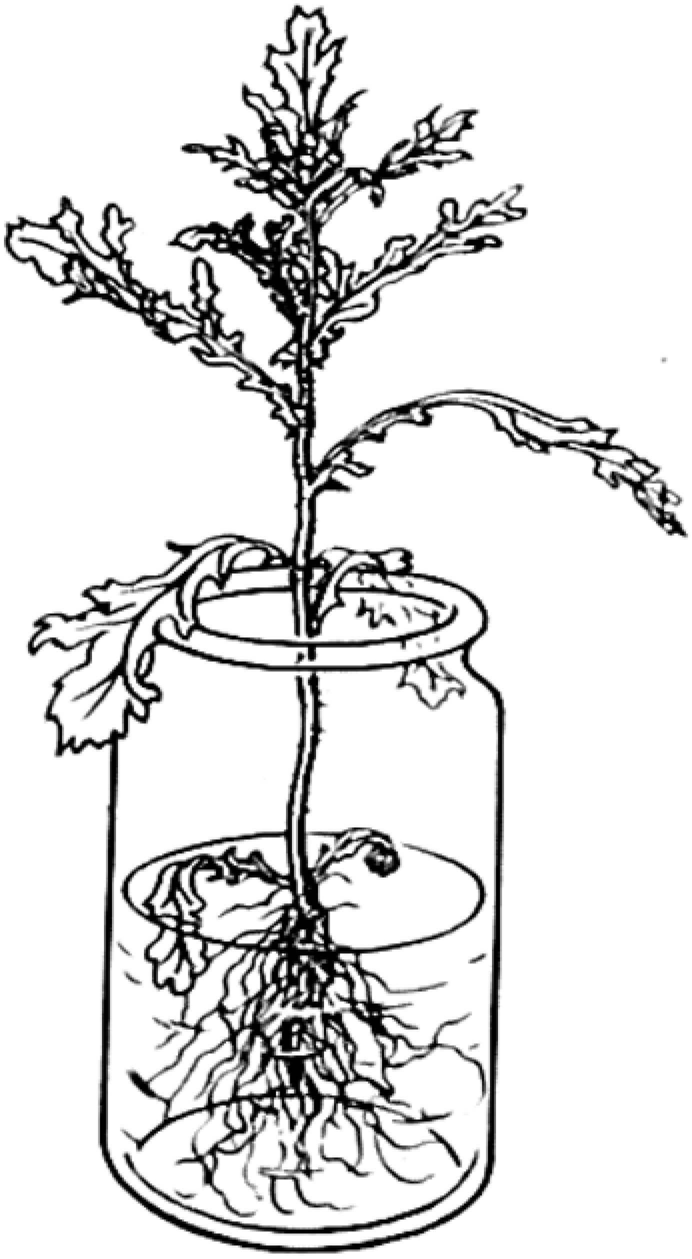
(*a*) Some sandy soil from ground that is never limed, e.g. from a hedgerow.
(*b*) Some from a field.
(*c*) Some from a good garden.

Put a handful of each of these soils into three separate jars, and after you have filled the jars with pure water (fresh rain-water will do quite well, but tap water is unsuitable) stir them up. Now put them on one side for a day so that the mud can settle. When the water is fairly clear, add a few drops of soil indicator to each jar and notice the colour. If it is green or blue, the soil is quite sweet, but if it is yellow or pink, the soil is sour and needs liming. Write the results neatly in your book and say where each soil came from.

This is a very simple, accurate test and you can always use it to find out whether or not your garden needs lime.

Experiment 6. To find out whether Plant Roots make Soil Acid when they breathe. We have found out that the carbon dioxide in our breath makes water acid, and we have learnt from our experiment with growing pea seeds (Chapter 1, Experiment 7), that plants also breathe out carbon dioxide. Do plant *roots* breathe, and, if so, do they make the soil acid? Our experiment will answer this question.

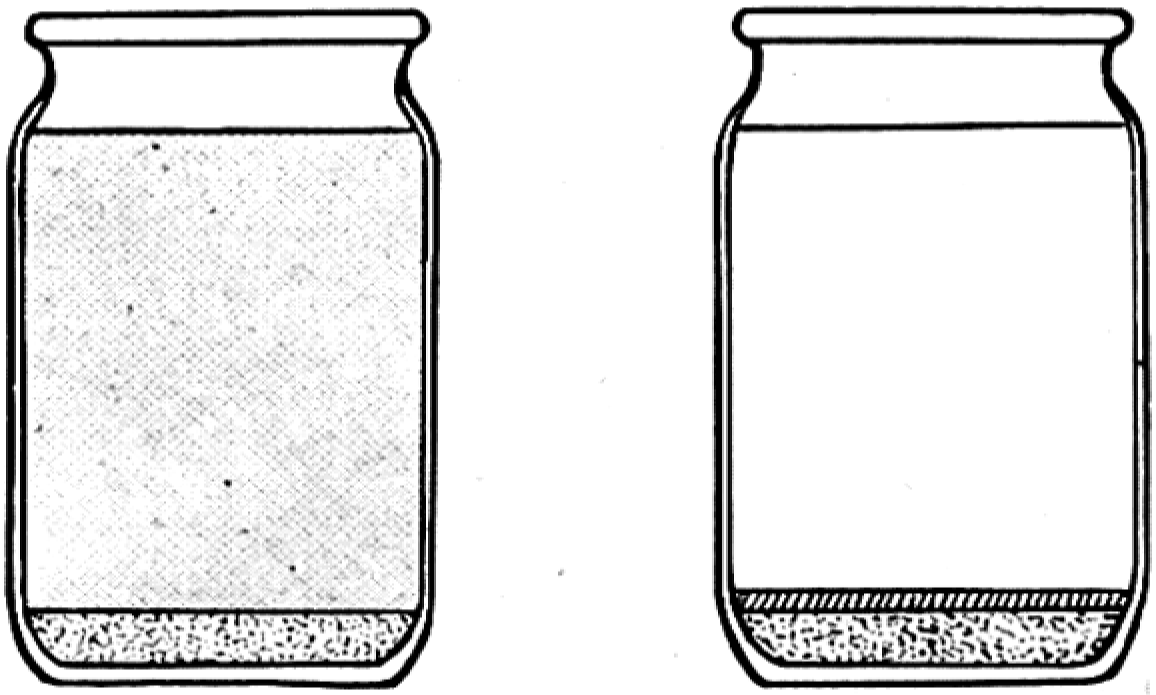
Half fill two jars with tap water and add a few drops of soil indicator to each one so that you produce the blue colour. Now take up a growing weed from the garden (groundsel or shepherd's purse will do), and when you have thoroughly washed all the soil from its roots, place it in *one* of the jars so that the roots are covered with water. Put both jars on one side for a whole day, and then look to see if there has been any colour change. You will find that the jar with no plant in it still has blue water. The water in the jar containing the plant roots, however, has gone yellow or pink. This shows that the roots have been breathing out carbon dioxide and that they do cause soil to become acid.


The living roots of the plant drink some of the water. Do they have any other effect on it?

Here, then, is a second cause of sourness in soils: not only does the rain make it necessary to lime our gardens and farms, but also the plants themselves make the soil acid.

Experiment 7. The Effect of Lime on Clay. You will often hear gardeners and farmers saying that lime makes clay soils easier to work. Let us examine the effect of lime on some clay soil.

Get a handful of heavy or 'clay' soil and stir it up with water in your jar until it is quite creamy. Put it on one side for a whole day. All of the sand will sink to the bottom, but the clay does not settle; it remains in the water, making it look very muddy. Now put in a teaspoonful of powdered lime and stir it up. You will find that the clay will go to the bottom quite quickly and the water is left quite clear in half an hour or less.



The sand goes quickly to the bottom of your jar of water but clay does not. How would you make the clay settle?

If you have ever worked on a farm or in a garden where the soil contains a large amount of clay, you will have learnt from experience how troublesome and difficult a 'heavy' soil like this can be! Sandy soils can be worked at any time of the year because the rain drains away quickly and the ground is never sticky. But no farmer would ever dream of going on to a clay field when it was wet. For one thing it would be too heavy to work because of the gluey nature of wet clay, and—more important still—his heavy implements would press the surface soil so firmly together that when the land did dry out it would set like bricks and he would not be able to make a seed-bed.

Why does the farmer plough his heavy land before winter sets in?

A farmer who has to grow his crops on heavy land of this sort has to take advantage of anything that will break the sticky clods into small 'crumbs' of soil. You have already learnt that the hard frosts of winter will do this, and a good farmer always ploughs his clay fields *before* the winter, so that the frosts can get into the furrow slices and break them down. Your experiment with muddy water has shown you that lime will help him too, because it destroys the stickiness of wet clay and makes it fall easily into crumbs. Here then is another important reason for putting lime on clay land—*it causes the clay to break down into small pieces or 'crumbs' so that a seed-bed can be made quite easily when the dry spring days arrive.* But the farmer always waits until his clay fields are dry before going on to them with his tackle, whether they have been limed or not; otherwise they will most surely 'set solid.' Here is an old farm saying:

March roll—April fool.

Can you see what it means?

Let us *summarize* the things we have learnt so far about lime and soil:

1. Soil is made sour by rainfall and by plant roots.
2. Lime is alkaline and is used by gardeners and farmers to neutralize the acid in soil.
3. Lime also destroys the gluey nature of clay and causes heavy clods to fall into fine crumbs.

You should learn these three facts by heart.

THINGS TO DO

(1) Write a composition entitled 'Lime is Necessary on Farm and Garden.'

(2) Use single sentences to answer the following questions:

- (*a*) Why does a lemon taste sour?
- (*b*) How do you know that rhubarb is not really a fruit?
- (*c*) If a liquid turns soil indicator yellow or pink, what can you say about it?
- (*d*) What is the name of the acid formed by carbon dioxide and water?

(*e*) Why does lemon juice lose its sourness when you stir bicarbonate of soda into it?
(*f*) What do we call a substance that neutralizes acids?
(*g*) What kind of substance is lime?
(*h*) What acid is there in rain-water?
(*i*) What are two of the things that make soils acid?
(*j*) By what two means are clay furrows made to crumble?

(3) Obtain a small quantity of:

(*a*) Common salt;
(*b*) Washing soda, and
(*c*) Soap.

Dissolve a little of each in tap water, and test to see whether they are acid or alkaline. Write down the results in three clear sentences, e.g.:
Common salt is —— because it turns soil indicator ——.

(4) Find three ponds or two ponds and a stream in your neighbourhood, and get a jar of water from each one. Use soil indicator to test them. Write down the results in three clear sentences, e.g.:
The water in (*name of pond*) is —— because it turns soil indicator ——.

If some of the waters are acid and some alkaline try to find out which of them has most plants and animals living in it. Write the result neatly in your book. (It is best to take the soil indicator to the ponds for this exercise.)

(5) Find out how much lime your farmer friend intends to put on his fields this year. Ask him if he will leave any fields without lime and ask the reason. Write down the answers in the form of a short paragraph.

(6) Take a handful of clay that has no sand in it. Divide this into two parts and mix a dessertspoonful of lime with one half, kneading thoroughly. Now mould a small dish with each portion of clay, and leave them in the sun to dry. When they are quite dry, fill them both with water. Record what happens. Can you give a clear explanation?

6

The Earth's Green Mantle

Green fields of England! whereso'er
Across this watery waste we fare,
Your image at our hearts we bear—
Green fields of England—everywhere.

A. H. Clough.

O all ye Green Things upon the Earth, bless ye the Lord!

Book of Common Prayer.

WHAT IS SUGAR?

YOU have learnt that all the sugar in the world is made in green leaves—the leaves of grass and the leaves of trees, the leaves of garden plants like cabbage, and the leaves of farm crops like wheat. All green leaves are busy making sugar during the hours of daylight. What substances do the plants use in order to make all this sugar? Think of all the sugar that the grocer sells. All of it has been made either in the large green leaves of sugar-beet plants or in the leaves of sugar-cane. The people in Britain use up hundreds of thousands of sacks of this sugar every year, and just as the cow needs to be supplied with food in order to make milk, so the plant needs to be supplied with some materials with which to make sugar.

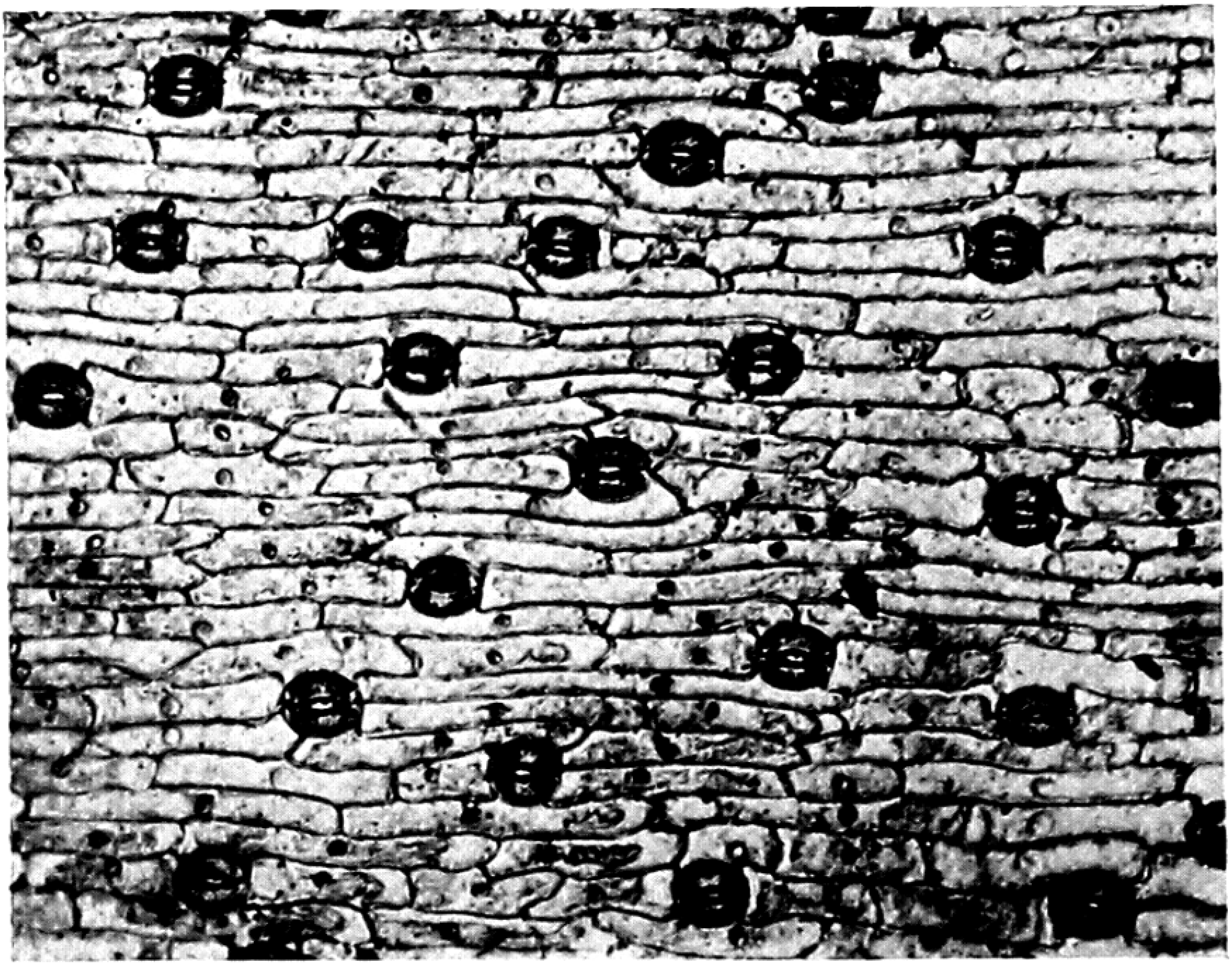
Experiment 1. To find out what Sugar contains. It is easy to discover that one of the necessary substances is CARBON. If you heat a little sugar in a tin lid or on an old spoon, the sugar very soon begins to melt; and if you go on heating it long enough, you are left with a piece of hard, black carbon. This must have been in the sugar to begin with. We say that it is one of the *constituents* of sugar.

It is not quite so easy to discover the other ingredient, however. In order to do so, you will need to make use of a glass flask or a metal-polish tin like the one you used for making oxygen in Experiment 4, Chapter 1. Fit it with a cork and a delivery-tube as before, and then attach a long piece of glass tubing (about 18 in.–24 in. long) to the rubber tube. Now place a little sugar in the tin.

When sugar burns a good deal of heat is set free.

When all is ready, fix the glass tube so that it slopes gently downwards and heat the tin with a spirit-lamp or a gas flame. The sugar will soon begin to decompose, and you will find that the inside of the glass tube becomes misted over with—WATER!

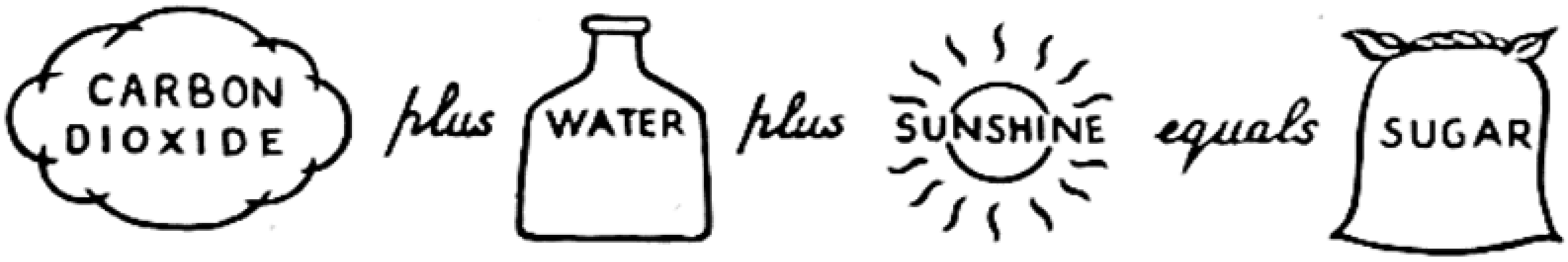
These two substances—water and carbon—have come out of the sugar; and by doing these experiments you have discovered the two materials that a plant needs in order to make sugar! But where does it get them from? You know already that the water comes into the plant through the roots and is carried up the stem to the leaves; but what about the carbon? In order to make such large quantities of sugar a good deal of carbon must be necessary, and you have been told that only tiny quantities of food material come from the soil along with the water. So that the carbon does not come from the soil! There is only one possible answer: *It must come into the leaves from the air surrounding the plant!* You have learnt that the invisible gas, carbon dioxide, contains carbon. Do you remember learning that when coke (which is carbon) burns away, it vanishes into the air in the form of carbon dioxide? The plant gets all the carbon it



This remarkable *micro-photograph* shows a tiny portion of the skin of a green leaf very highly magnified. The joints between all the cells are airtight, but look at the dark patches. Each one has an open pore in the middle.

needs to make sugar from carbon dioxide in the air. This gas goes into the plant through the millions of tiny holes that are to be found underneath each leaf.[1]

Inside the leaf, the water and the carbon dioxide come together and the wonderful process of sugar manufacture begins. Sugar is not the only product of this remarkable change, however; both water and carbon dioxide contain oxygen, and when the sugar is being made some of this oxygen is set free. Let us write down what happens in the form of an equation:



Only green plants can make sugar; remember the strange ingredients!

Carbon dioxide + Water = Sugar + Oxygen.

It will seem strange indeed to you that our valuable sugar is made from nothing but 'air and water'—but so it is. You would think that some of our clever manufacturers or scientists could discover a way of doing this so that human beings could make their own sugar from air and water; there would never be any shortage of sugar then! But nobody knows exactly how green plants make sugar and man is quite unable to copy the process. In every field, along every hedgerow, and in every woodland—wherever, indeed, there is a green leaf, large or small, the secret process is going on; and enormous quantities of sugar are being made each day. Do you know how much sugar is stored up by a field of sugar-beet plants during one summer? About two tons for every acre! This means that in one season the green leaves of the sugar-beet plants on a small ten-acre field make enough sugar for their own needs and enough to fill about four hundred sacks in addition. And all this from water and carbon dioxide!

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[1] *Most* plants have the majority of their stomata or pores on the underside of the leaf. Quite a number of plants, however, have stomata on the upper side of the leaf and on the stems as well. Also, it is important for you to know that the leaves of water plants that grow beneath the surface of the water have no stomata at all. How does the necessary carbon dioxide get into them? Remember that gases can dissolve in water; and there is a good deal of carbon dioxide in river water, pond water, and so on. The leaves of water plants are able to *absorb* water and plentiful supplies of carbon dioxide go into the leaves along with the water they absorb.

This is a crop of sugar-beet. All the sugar is made in the green leaves.

This remarkable process can only go on during the hours of daylight and it stops altogether during the hours of darkness. The green leaf needs light in order to *combine* the carbon and the water into sugar. That is why you never see green plants flourishing in cellars and caves and other dark places.

WHY IS SUGAR A FOOD?

Do you know what is meant by saying that a boy or a girl or any person is *energetic*? It means that the person you are thinking about is full of energy—he can do a lot of work, or run about easily, or play games hard without getting very tired. Nobody is able to say what energy *is*, but everybody knows what it *does*. It enables you to do work or to keep warm. When a horse is drawing a plough it is using up energy, and so is a tractor. The horse gets its energy from some of the food you give it, and the tractor gets its energy from the petrol or paraffin you put into the tank. When all the food or all the petrol has been used up, you have to supply more, otherwise no more work will be done. You wouldn't expect your tractor to go without fuel. Nor can you expect a horse to work without food. Energy is locked up inside the horse's food, and you have already learnt how living things unlock the energy in the food they eat. They do it by 'burning' it up when they breathe. That is what breathing is for!

The oxygen that the horse breathes in gets to the sugar in his blood and combines with it to form water and carbon dioxide again. And, as you know, the water and carbon dioxide come out in the horse's breath. Look at the picture and notice the clouds of water that he is sending out as he pants his way across the field on a cold winter's day! When the sugar is burnt up by breathing, the energy that was locked inside it is released and the horse uses this energy to keep warm and to pull the plough. We

On a cold day you can see the water that living creatures breathe out.

can now write down, in the form of another equation, just what happens when breathing takes place:

Sugar + Oxygen = Carbon dioxide + Water + *Energy*.

You will now begin to understand what food is. First of all it is something that an animal can eat; but it is more than that—it must also contain energy, so that when the animal breathes this energy can be set free inside its body. And this is why sugar is a food—*it can be eaten, and it contains energy that can be set free by breathing*. Of course, many foods have other uses as well; they are used for growing new parts—muscles or hair or bones. And in the case of plants—new leaves or roots and so on; but you must remember that *some* of the food that animals take in is used to provide them with energy. (You may wonder where horses get their sugar from, as we never give them sugar in their regular rations! You will learn about this later on in the chapter.)

HOW THE ENERGY GETS INTO SUGAR

You now understand why sugar is a food, and we must next inquire where it got the energy that is in it. When the carbon dioxide and water are combined together in the leaf to make sugar and oxygen, energy gets locked into the sugar that is formed; and when, during breathing, the sugar and oxygen unite to form carbon dioxide and water again, this energy is set free. (It is rather like catching a butterfly with a jar and a lid! When you bring the two together the butterfly is caught, and when you take them apart again the butterfly is released!) Where did the energy in the sugar come from to begin with? The answer to this important question will enable you to understand why green leaves cannot make sugar in the dark. *Light itself is a form of energy*—just as heat and electricity are—and when the green leaf brings the carbon dioxide and water together, it 'locks up' some of this light-energy inside the sugar that is made. It is because light-energy actually goes into the sugar that the green leaf cannot possibly go on making this food in the dark. We shall never forget the importance of light-energy in sugar formation if we learn this equation:

SUGAR FORMATION IN GREEN LEAVES

Carbon dioxide + Water + Energy (sunlight) = Sugar + Oxygen.

COULD WE MANAGE WITHOUT PLANTS?

Plants do not, of course, make all this sugar just for animals and human beings to eat. They use most of it themselves to make new parts. It can be changed by them into the various materials necessary for making flowers, roots, stems, and leaves. Small quantities of other substances have to be 'added' to the sugar in order to make these new parts, but sugar is the main ingredient, just as water is the main ingredient in the 'pop' you enjoy drinking on a hot summer's day. Even wood is made mostly from sugar!—which means that the solid limbs of every great tree and the timber of your desk began their existence in green leaves—and that carbon dioxide and water were the main raw materials from which they were made! (You know that if you set fire to wood it burns away, and you can quite easily see the black carbon in it when it is only partly burnt.) Can you think of anything else that came from sugar in the same way? What about the paper in the book you are reading or the cotton of which your handkerchief is made? These things, too, are made from plants, and began their existence in a green leaf one sunny day. If you burn them they will be returned to the atmosphere in the form, largely, of carbon dioxide and water, while the energy that they contain will be released in the form of heat and light.

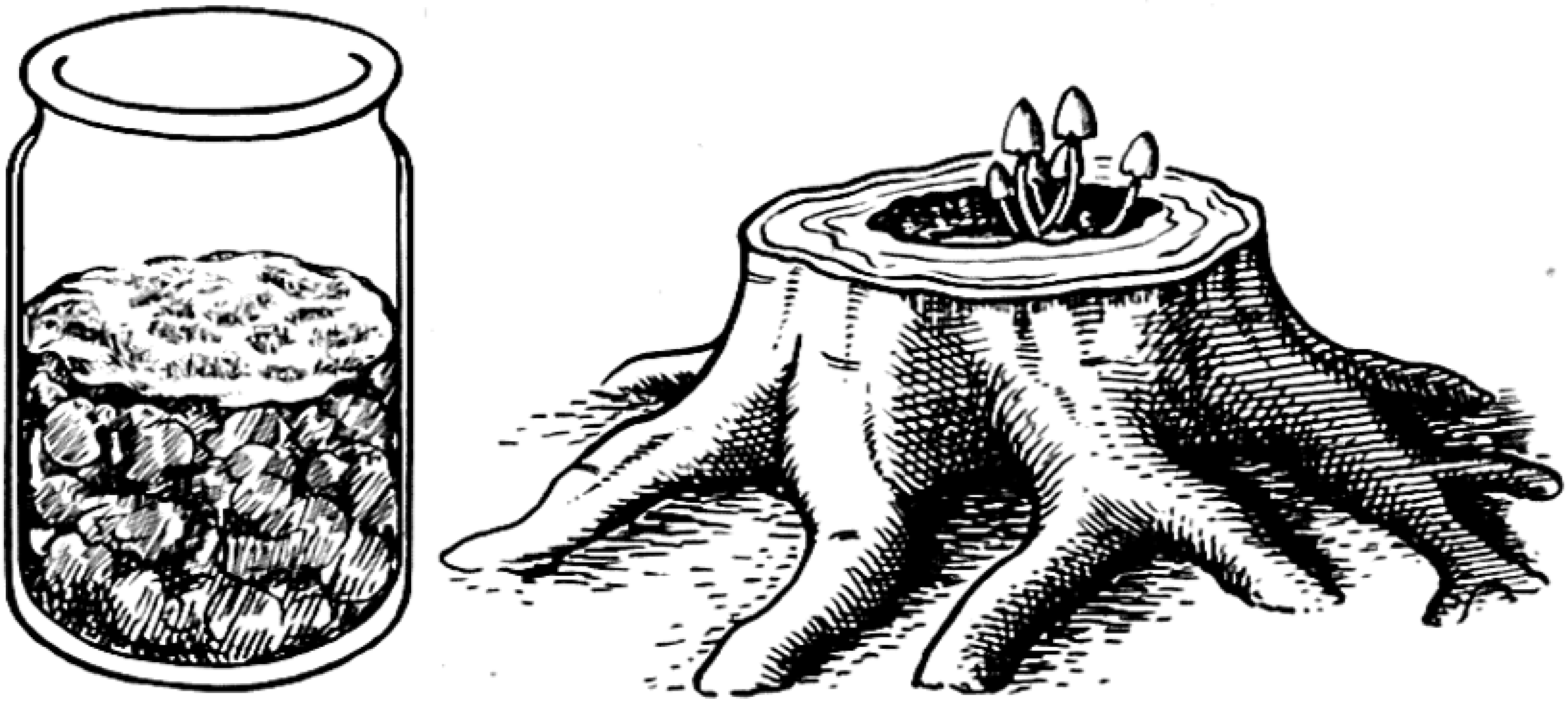
Let us try to imagine what would happen if all the green plants in the world suddenly ceased to exist. What about the animals that live entirely by eating plants—cattle and sheep, for example? They would disappear, too, because there would be no food for them. That means that we should have no beef or mutton, no milk or butter or cheese, and no wool for our clothes. All these things, you see, are made largely from sugar in the first place, because cattle and sheep build their bodies and make their milk and so on out of the plants that they eat. Indeed, if there were no green plants in the world, all the living things that you have ever seen or heard about would vanish and the earth would become barren and desolate!

It is strange to think that all the living things we see around us—all the plants and animals—the flowers in your garden, the cattle grazing the meadows, and the birds singing in the trees, owe their very bodies to the work being done in the leaves of the earth's green mantle; and that all their energy comes from sunshine that is absorbed by green leaves during the process of sugar formation. Nature is wonderful indeed. If we could copy nature's sugar-making process, we could perhaps do without the green world of plants—but man has so far failed to copy the work of *green* and *living* leaves. Nature holds her great secret, and the life in the tiniest weed is something that man cannot understand. We can improve our plants by careful cultivation and by careful breeding, but we cannot give them life.

HOW SOME PLANTS, AND ALL ANIMALS, GET THEIR SUGAR

Perhaps you have already begun to wonder about plants that are not green at all. And there are many of them—mushrooms and toadstools and the moulds that grow on bread and in pots of jam and so on. All these things are plants, but they have no green leaves.

They are quite unable to make sugar for themselves, and for this reason they do not need to live in the light. Mushrooms will grow quite well in a dark cellar, as you know. Do they need sugar in order to grow, and if so, how do they get it? These *fungi* do need sugar, but they get it second-hand, just as animals do! They feed upon the dead remains of green plants that have been made largely from sugar. You know that mushrooms grow quite well in places where there is some horse manure or cow manure. Now the dung of cattle and horses is really that portion of their plant food that they have not used up or *digested*, and it contains substances that can be turned back into sugar.



Moulds and toadstools are plants; but they are not green. How do they get their sugar?

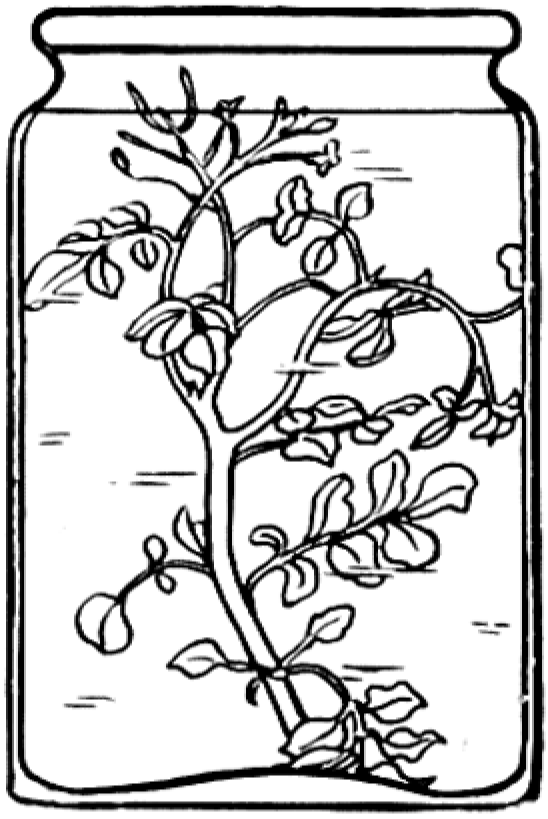
The mushrooms are quite able to *extract* this second-hand sugar from the dead remains of plants, and they flourish exceedingly well on it. You may sometimes have seen toadstools growing on the old stump of a dead tree. There is no manure in the tree stump for these toadstools to use, but the rotting wood came largely from sugar in the first place; and it is from this dead material that the toadstools get their sugar and other food. So it is also with the many moulds that you see on jam and bread and on leather. (Even leather came from green plants to begin with; the animal that made it—maybe a sheep or a horse or a cow—had to eat plant foods in order to make its leathery skin.)

When we were talking about horses getting energy from their food, it was said that by breathing in oxygen they were able to 'burn up' the sugar in their blood and so release its energy for working and keeping warm. Horses are fed on things like hay and oats and beans, and there does not seem to be any sugar in these foods. Remember, however, that all the parts of a plant are made mostly of sugar, and this is true of oats, beans, hay, and other plant foods that a horse eats; when the horse eats these foods, it is able to change them back into the sugar and other substances out of which they were originally made!

In just the same way, you yourself are able to extract sugar from the bread and potatoes that you eat. This is exactly what we mean by digestion. All the rice pudding and porridge that you eat contains starch; this starch was made from sugar, and it has to be turned back into sugar by your digestion before it can get into your blood—where it has to be before you can get the energy out of it. So you see, there is no real *need* for you to eat sugar itself, as you can get plenty of it from starchy foods like those you have just read about. However, we like sugar for its sweetness as well as for the energy it contains, so perhaps there is no need for you to be too hard on yourself! But the next time you enjoy a sweet, remember where the sugar in it came from!

TO SHOW THAT CARBON DIOXIDE IS USED UP BY THE LEAVES OF GREEN PLANTS

Experiment 2. For this experiment you will need a jar, some soil indicator, and a fresh, green, water plant of the kind you can see growing beneath the water in brooks and ponds. A sprig of *fresh* watercress will do quite well.



The green leaves of the plant soon use up the carbon dioxide that is dissolved in the water.

Almost fill your jar with tap water and put in several drops of soil indicator to get the blue colour. Now bubble some of your breath into the water through a clean tube of some kind. As the carbon dioxide dissolves the colour will change to yellow or pink because the gas makes the water acid. When this happens there is plenty of carbon dioxide in the water. Put the water plant into it so that all the green leaves are below the surface. Place the jar in a good light by the window and leave it alone for some time. What happens? The colour gradually changes back to green or blue, showing that the carbon dioxide has been removed by the green plant!

In order to make quite sure that it *is* the plant that removes the carbon dioxide, it is a good plan to have another jar full of the yellow-coloured water standing in the window at the same time. You will find that the colour of this water does not change, and this is because the carbon dioxide in it is not used up.

Remember why the plant uses up this carbon dioxide—the leaves use it to make sugar.

THINGS TO DO

(1) Imagine yourself to be a tiny drop of water coming down in a shower of rain. After many years you become part of the leather in a pair of shoes. Tell the story of what happened to you in between. Don't forget to say where you fell to earth at the beginning, and also who bought the shoes at the end.

(2) Use single sentences to answer the following questions:

- (*a*) Where is all the world's sugar made?
- (*b*) From what two substances do green plants make sugar?
- (*c*) Where does the green plant get these substances?
- (*d*) How do they get into the plant?
- (*e*) What else does the green leaf need also in order to make sugar?
- (*f*) Why is sugar a food?
- (*g*) How do animals release the energy from the sugar in their blood?
- (*h*) Why are mushrooms unable to make sugar?
- (*i*) How do mushrooms get the sugar they need?
- (*j*) How can you get sugar into your body without eating any?

(3) Write down these two headings side by side on one page of your book. Now think of the substances of which the things you wear are made. Put the names of these substances under the correct heading.

FROM PLANTS (*direct or via animals*)	FROM OTHER SOURCES
e.g. Wool	Iron (shoe nails, etc.)

(4) Make a list of the foods you eat in two columns labelled:

	PLANT	ANIMAL
e.g.	Potato crisps	Jelly

PREPARATION FOR WORK TO BE DONE IN CHAPTER 7

1. You will require to soak in water some seeds of the runner bean or broad bean for your next lesson. Place a few under some damp flannel for a few days, and take care to keep the flannel damp all the time.
2. Arrange the following apparatus so that it will be ready for use in a week or ten days:

   Take two clean 2-lb. jam jars and line them with blotting-paper. Now fill them both with loose soil or damp sawdust, taking care not to get any soil or sawdust between the glass and the blotting-paper. When you have done this take a dozen broad bean seeds, using six for each jar; insert them on the outside of the blotting-paper as shown in the drawing on page 106. The soil or the sawdust—whichever you use—should be damp enough to make the blotting-paper moist, and you should add a little water from time to time, so as to prevent the paper from drying. Place them on a window sill in a warm room.

7

The Baby Plants

Some seeds fell by the way side, and the fowls came and devoured them up . . . but other fell into good ground, and brought forth fruit, some an hundredfold, some sixtyfold, and some thirtyfold.

St. Matthew xiii. 4–8.

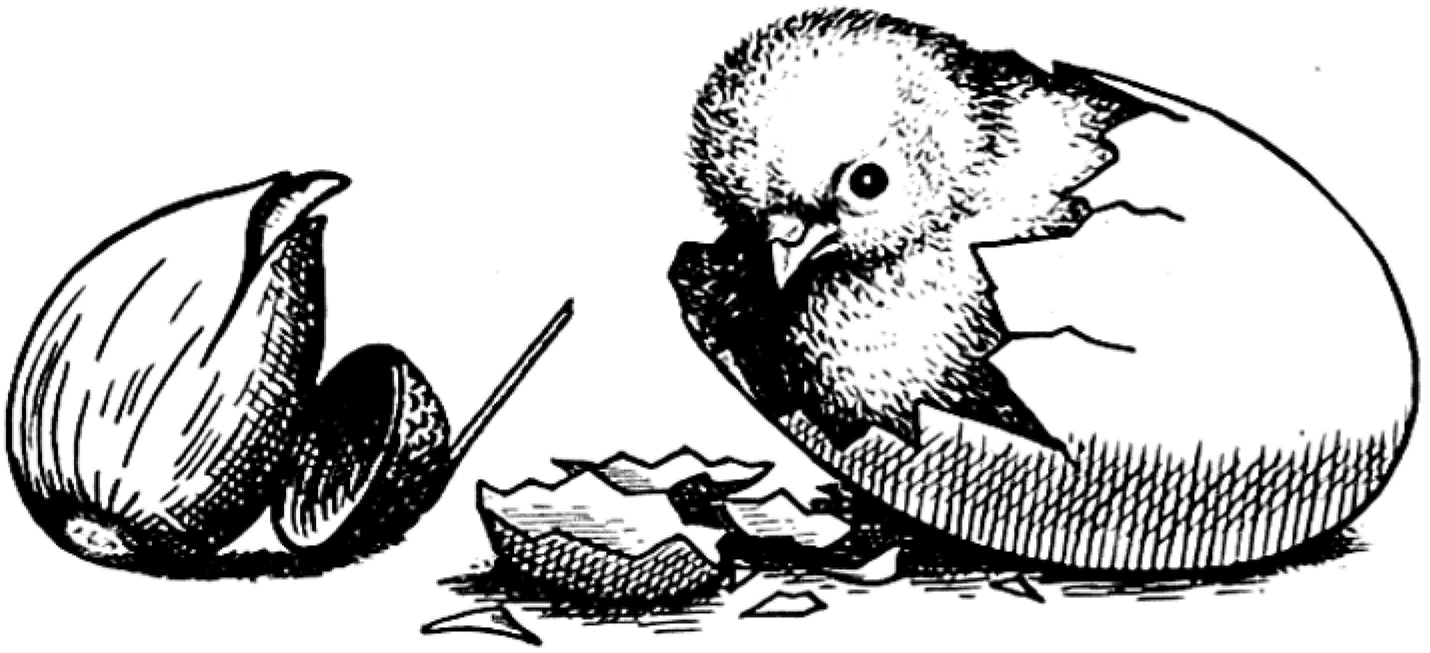
Desire not a multitude of unprofitable children.

Ecclesiasticus xvi. 1.

IN YOUR country walks you must often have seen the tiny leaves of baby plants pushing their way through the soil. Sometimes these tiny newcomers cluster in large numbers round the base of the parent plant; and plants like the foxglove may often be seen standing—as if proudly—on the little mat of green that covers the soil around their dying stems. The seeds of some plants, however, are scattered far and wide—maybe by the wind or maybe by some bird—and you will find them beginning to grow in solitary splendour far from the plant that gave them birth. Some of the wild seedlings are quite small, and some, especially those of trees like the beech or the sycamore, are quite large; but, whatever their size, they have all begun life as a seed—and every seed contains a baby plant. If we examine a large seed—like that of the broad bean—we shall be able to see the different parts of the newcomer quite clearly, so get some of the seeds that you soaked in water last week and let us examine them.

EXAMINATION OF A SOAKED BEAN SEED

Before you soaked the seed in water, the outside covering was very tough indeed; this covering is intended to serve the same purpose as the shell of a bird's egg—that is to say, it is a protective covering for the living part inside. Not many insects could eat their way through this leathery jacket to the valuable food stores within—stores that will be needed by the baby plant when it begins to grow and without which it would perish. The time will come, however, when its good services will be no longer needed. As the seed swells and grows, the TESTA—as this covering coat is called—will be split open and be discarded, just as the shell of an egg is cast aside when the young chick or nestling comes out. Let us take a more careful look at it. Somewhere on its surface you will find a small scar. Can you think what this is? Remember that when the seed was growing inside the fruit (in this case inside the bean pod), it had to be connected to the parent plant so that it could



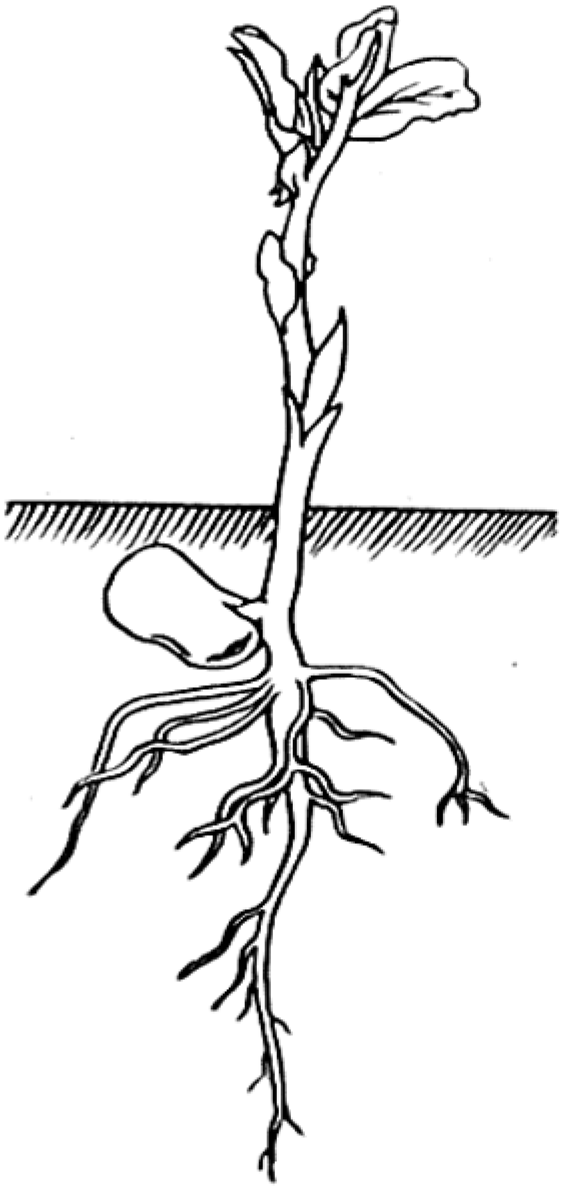
Baby plants and baby birds start life in much the same way.

receive food. This scar, which is called the HILUM, was made when the seed broke away from the pod. All seeds have scars like this, but it is not easy to see them on very small seeds unless you use a magnifying glass.

You know that the seed will need moisture when it begins to grow. How does this water get through the testa? If you squeeze your moist bean you will notice that a drop of water comes out through a tiny hole near the hilum, and it is through this hole that the seed is able to suck in the water it needs when it first begins to swell. Of course, this hole—it is called the MICROPYLE—has to be very small indeed, otherwise it would allow insects to enter, but it is quite big enough for the needs of the plant and water will go through it quite easily, as you see for yourself.

Now let us strip off the testa and examine the contents. The baby plant fills the whole of the interior, and in the case of the bean it is quite white. It will open out easily like a book, so that you can see two fleshy parts. These are the food stores, and they are called the seed-leaves or COTYLEDONS. They are really fleshy leaves, and you will see that they are attached to a small object that is pointed at one end, and has the appearance of a tiny brush at the other. The pointed end is the baby root that will push its way into the soil when the seed begins to grow, and the other end is the baby shoot that will push its way up through the soil into the air and sunlight. It doesn't matter which way up the seed falls into the soil; the root always goes downwards and the shoot always finds its way upwards! This is quite wonderful, and nobody knows quite how it happens—it is another of nature's secrets!

When the baby plant begins to grow, the food in the two cotyledons will be changed back into sugar and other substances; and it will be used to make the new root and the new shoot, because, of course, until the seedling has made some green leaves it can't make any sugar of its own. There is enough food in the cotyledons to make one or two green leaves, and then the seedling can get along quite happily making its own food in the sunshine. Sometimes the cotyledons are pushed up through the soil along with the growing shoot, and when they reach the light they may turn green themselves and begin to manufacture extra food to help the young shoot along. This happens in the case of many small seeds like those of mustard and cress, and quite a number of annual flower seeds behave in the same way. In addition, there are a few seeds whose cotyledons are quite green before they come out of the testa at all! If you open the seed at the base of a sycamore wing you will find a good example of this—the long, green cotyledons are rolled up inside the testa and look rather like a watch spring. Great numbers of seeds, however, keep their cotyledons below the surface of the soil, and the first green leaves are grown by the baby shoot. This is what your broad bean does.


There is enough food in the seed to start the young plant on its way. After that it must fend for itself.

You should notice that a good deal of the food we feed to farm animals, and much of what we eat ourselves, was really intended by nature for the use of the baby plants. Think of the oats and barley that we give to farm stock; and of things like bread, porridge, peas, beans, rice, and so on that we use ourselves. Cattle cakes, too, are made largely from seeds, and even the olive oil that we use on salads comes from the fruit and seeds of the olive-tree. (Why is it not possible to include potatoes in his list?) We also eat coco-nuts, which are the seeds of the palm-tree, and the white part that you eat is the food store. The coco-nut is the largest seed in the world, and it not only contains a good supply of food for the young plant—it contains a supply of water also. That is because the coco-nut palm-tree grows in parts of the world, like India, where the weather may be very dry for a long time and the large seedling of this tree needs a water supply of its own in case of drought. You should remind yourself that all seeds are built more or less on the same plan as the bean seed you have examined: they contain a young root, a young shoot, and a food store of some kind.

WHAT DOES A SEED NEED IN ORDER TO BEGIN GROWING?

You should by now see many changes in the broad bean seeds that you were instructed to place in jars (page 98). They have begun to grow, or *germinate.* We use the word *germination* for the beginnings of growth shown by a seed of any kind. Before we examine the young seedlings more carefully let us think of the conditions that are necessary before the baby plant will awaken from its 'sleep.' For asleep or *dormant* it has surely been for many months. Some kinds of seed can remain dormant for a very long time—wheat, for example, can be grown from seeds that are fifteen or sixteen years old, and the seeds of some weeds can remain in the soil for many years before springing into renewed life. This is not true of all seeds, of course, and it is generally advisable to have fairly new seeds for farm and garden crops.[1]

One of the things necessary for germination is water. No seed will begin to grow if it is kept quite dry. Indeed, plants need water not only at the seedling stage, but all through their lives. This is why sandy deserts have no plants growing on them—they are too dry to *support* plant life. The bean seeds in your jar could only begin to grow after you had given them a supply of water. Do they need anything else? Let us carry out another experiment.

EXPERIMENT TO SHOW THAT SEEDS NEED AIR FOR GERMINATION

Fill a bottle with water that has been boiled and then cooled. (The boiling drives out any air that is dissolved in the water.) Now place a dozen bean seeds into it, cork it up, and leave it on a window ledge. Watch carefully each day to see what happens.

After a time the seeds begin to swell and look as if they will germinate; but before many days are over they cease growing and very soon begin to rot. This experiment shows you that seeds need air as well as water in order to germinate. And this is just what you would expect, because you have already learnt that growing plants need to breathe.

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[1] It is not uncommonly said that wheat seeds found in the tombs of the Pharaohs of Egypt—seeds supposed to be thousands of years old—have been grown successfully. This, of course, is quite untrue. No seed could possibly remain alive for such a long period of time.

The bean seeds that you germinated in the jarful of soil were given plenty of water and plenty of air as well. Can you think of any place in which they would *not* have grown even after you had given them these two things? They would have grown quite well in the darkness of a cupboard, because they are usually underground when they begin to germinate. But suppose you had put them outside on a frosty day, or in a refrigerator? They certainly would not grow in such low temperatures. The third necessary condition, then, is sufficient warmth; and if you give any living seed these three things:

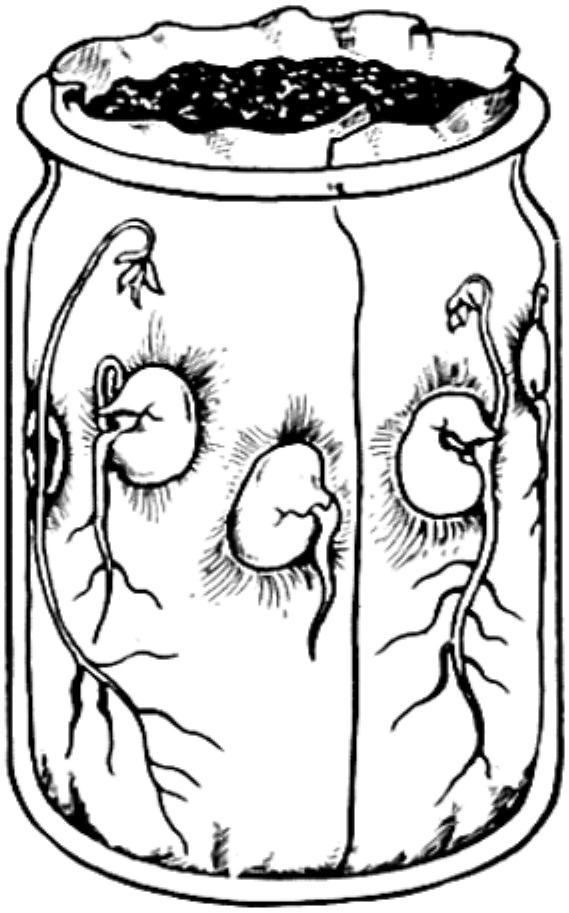
Water,
Air, and
Warmth,

it will burst into life and begin to send out its young root and shoots.

THE PARTS OF A SEEDLING BEAN

Now let us have a look at the growing seedlings. If you watched them when they were just beginning to grow, you would notice that the young pointed root appeared first, and that whichever way up you had put the seed, this root soon began to grow downwards. After a day or two little branch roots began to grow off this main *tap root*, and about the same time the young growing shoot began to show itself through a split in the testa.

Did you notice the shape of this shoot? It was bent over like a hook. When the bean is growing in soil this bend in the young shoot is very necessary, as it allows the tender young leaves to be dragged up through the soil instead of being pushed against it. You know what happens if you pull your paint brush along the paper when you are painting—the hairs remain all together; but if you push it, they open out and spoil the shape of the brush. In the same way, if the young shoot pushed the little 'brush' of leaves up through the soil, they would be spread apart and perhaps broken off. As soon as this *plumule* reaches the air, however, the bend in the shoot straightens out and the growing stem becomes erect. If you watch other seeds growing, you will find that they all behave in the same way. It doesn't seem that nature forgets anything! Not even the smallest detail such as this.



The ascending shoots of these young plants are bent over. Can you give the reason?

If you examine the roots closely you will see that each one has a woolly tuft growing just behind its tip. You may easily confuse these tufts with moulds like those that grow on bread; but they are nothing of the kind. They are tiny hairs—we call them *root hairs*—and it is through these minute hairs that the plant takes in all its water from the soil. No water can get into the plant through any other part of the root, and if these hairs are destroyed in any way new ones have to be grown before the plant can get any more water.

Have you ever noticed how careful the gardener has to be when he is transplanting things like young cabbages? He tries to avoid knocking all the soil away from the roots, so that these fragile hairs shall not be broken off. You see, if the plant still has these root hairs when it gets to its new home, it can begin drinking in water right away without check. But if they all get broken off, it is very probable that the plant will droop for want of water, and will only begin to pick up again when a new set of these tufts has been grown. This is why transplanting is such a tricky operation.

NOW LET US TURN OUR ATTENTION TO THE GROWING SHOOT

Do you notice how quickly the new young leaves begin to turn green—and parts of the stem too? As soon as they unfold they change their colour so that they shall lose no time in beginning to make sugar for themselves. It is as though the plant knew quite well that the cotyledons contain only a limited supply of food, and that it must set to work quite quickly to make additional sugar. Of course, the bean seed is quite a big one, and it contains enough food to make long roots and shoots. That is why it can be sown quite deep down in the soil. But smaller seeds need to be much nearer to the surface, because there is not enough food stored in them to make long shoots. If you sow small seeds too far down in the soil, what happens? They begin to grow quite well, but all the food in the cotyledon gets used up before the young shoot gets out into the air and sunlight, and, of course, the buried seedling dies because it cannot even begin to make sugar for itself.

EXPERIMENT TO SHOW THAT SHOOTS GROW UPWARDS WHILE ROOTS GROW DOWNWARDS

When most of the bean shoots in your jars have grown about two inches above the top of the glass, lay the jars on their sides near the window once again. Observe both shoots and roots carefully each day for a week. You will see that the shoots turn upwards and the roots inside the jars turn downwards, while the cotyledons, which haven't moved at all since the plants began to grow, remain just where they were when you put them in.

THINGS TO DO

(1) Write a paragraph entitled 'How to Transplant Cabbages.'

(2) Write single sentences in answer to the following questions:

- (*a*) What do we call the outer covering of a seed?
- (*b*) What parts can you see when you examine the baby plant inside a bean seed?
- (*c*) Does it matter which way up a seed is sown?
- (*d*) How does the seedling make use of the solid food inside the cotyledons?
- (*e*) Do the cotyledons remain under the soil when a seed germinates?
- (*f*) Why should tiny seeds not be put too far down in the soil?

(*g*) What three things does a live seed require in order to germinate?

(*h*) Why does the young shoot of a seedling remain curved while it is under the soil?

(*i*) Through which part of the root does a plant get its water?

(*j*) Can you name a seed that has green cotyledons?

(3) Make a list of foods—used by humans—but really intended by Nature for the feeding of baby plants and animals. Put the name of these foods under two headings:

Intended for Baby Plants	*Intended for Baby Animals*

(4)

A FASCINATING HOBBY

Collect the seeds of as many different wild plants as you can and sow them in pots or seed boxes nearly full of soil. When the seedlings appear make neat drawings to show the shape of the cotyledons if they come up above the soil, or of the first green leaves if they do not. Most of these shapes are unknown so that you will be doing new work in the world! Put the name of the plant beneath each drawing.

Transplant some of the seedlings—when they get bigger—and see if you can keep them alive until they are big enough to bear flowers.

(5) Put pieces of soaked flannel or blotting-paper on two saucers. Now place 100 wheat grains on one and 100 mustard or cabbage seeds on the other. Add a little water each day to keep the flannel or blotting-paper moist. Leave them to germinate, and after ten days count the number of seedlings. This is the way in which samples of seeds have to be tested before they are sold.

8

The Honey-bee and Some Other Insects

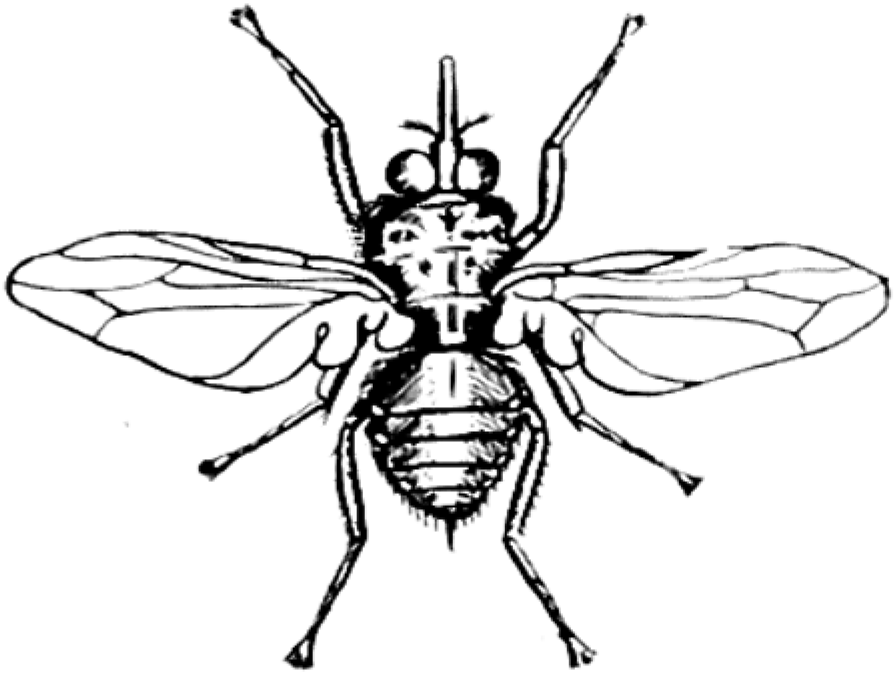
Where the bee sucks, there suck I.
In a cowslip's bell I lie;
There I couch when owls do cry.

SHAKESPEARE.

Patience, flea, the night is long!

OLD SPANISH PROVERB.

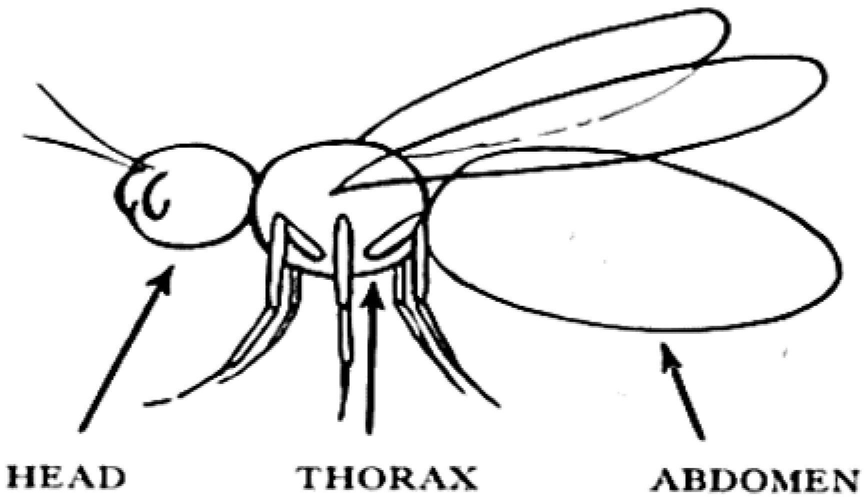
THE honey-bee belongs to that very large group of animals that we call insects; and it is a very large group indeed. There are more than twenty thousand different kinds of insect in this country, and a list of their names alone would fill a very much larger book than the one you are reading. Some of these creatures are—like the butterfly—very beautiful indeed and are a constant pleasure to us. Others, as you know, are quite ugly; and some are at times a harmful nuisance. But beautiful or ugly, useful to man or a pest to him, they are all quite marvellous beings, though we have to treat some of them much as we treat weeds in the fields and destroy them whenever we can. Some of them carry dread diseases. The Black Death of the fourteenth century (1348–9) killed half the people in England, and it was caused by a disease known as the plague. This disease was carried from person to person by a flea that bites both rats and human beings, and it was necessary to kill rats in large numbers in order to get rid of the disease-carrying flea. Many *tropical* insects carry dangerous diseases, and great efforts are made to keep these insects under control. The tse-tse fly of Africa carries the germs of sleeping-sickness in its blood, and when it bites human beings the germs are handed on and the victims become very ill indeed. Perhaps you have heard also of the disease malaria which is carried from person to person by a blood-sucking mosquito. In hot countries where this mosquito is prevalent, it is necessary for white men to put a mosquito-net over their beds at night to keep the insects away. However, it is only by a careful study of the ways and life stories of these insects that man is able to control them, and if we just regarded them as 'nasty' and did not try to understand their ways, we should not be able to prevent the damage done by the harmful ones or make use of those that benefit us in some way.



Tse-tse flies live only in the tropics, where they carry the dangerous sleeping-sickness. The actual fly is much smaller than this drawing.

WHAT IS AN INSECT?

Before learning about the wonderful things going on inside a hive of bees, let us find out a little more about insects in general. First of all, what is an insect and in what ways is it different from other animals? Let us think of any fully grown insect that we know—a house fly, or a bee, or a butterfly. In each case the body is divided into three parts. At the front end there is the HEAD, which carries the mouth, the eyes, and the feelers or *antennae*. In the middle comes the part called the THORAX—to which the legs and wings are attached. All insects have *six legs*, but the number of wings varies. Some of them have four wings (e.g. butterflies and bees), some have two wings (e.g. house flies), and some have no wings at all (e.g. the flea). Behind the thorax comes the longest part of all—the ABDOMEN. Any creature at all that has these three parts and has six legs is a fully grown insect. (Is a spider an insect?) Another very important feature for you to notice is that they have no bony skeleton inside their bodies such as many other animals have. Instead, they have a hard outer covering which serves the purpose of a skeleton and holds them in shape.

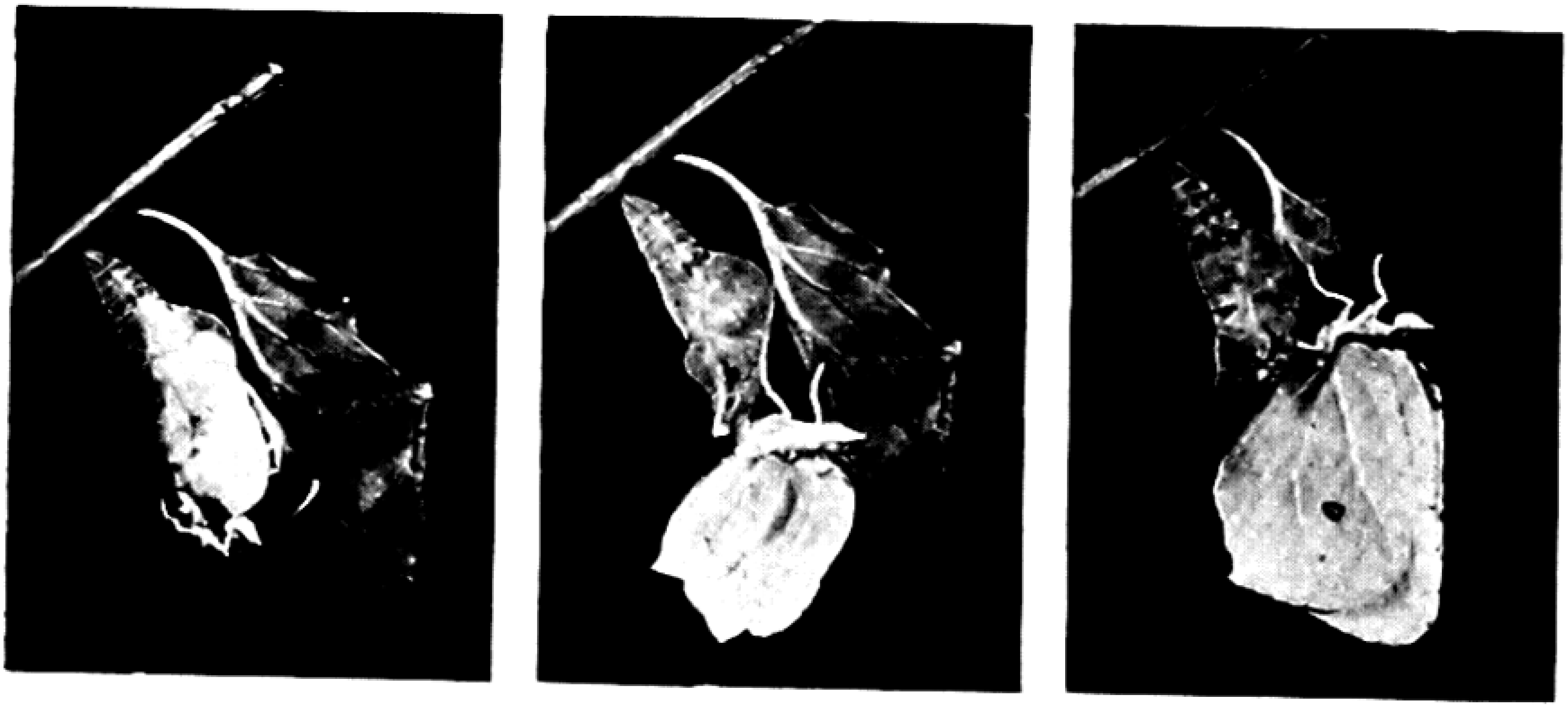


The three parts of an insect's body can easily be seen.

HOW AN INSECT GROWS UP

You will notice that we have been talking about fully grown insects. This is because the young ones usually look quite different from their parents. So different, indeed, that you might easily think that they were different creatures. Nobody would guess that the various caterpillars to be seen feeding on plants are really young butterflies and moths, or that the maggots to be found in decaying flesh are really young flies. But they are. It is important for you to remember that whether you are looking at the caterpillar or the full-grown butterfly you are looking at *the same insect*. Each of these insect 'grubs' is called a LARVA, and all insects pass through this stage. It is really the growing stage, and the larvae of all insects eat a great deal of food in order to grow rapidly. When growth is complete, a wonderful change takes place, and each larva turns into a fully developed insect. Thus a caterpillar that came from a butterfly's egg becomes a butterfly, a maggot that came from a wasp's egg becomes a wasp, and so on. Once this final change has been made, the insect will grow no more. Some people think that small flies or beetles will grow up into bigger ones, but this is quite a mistake. Once the insect has entered this final stage of its life, it will grow no more! All the growing is done in the *larva* stage.

This wonderful change from larva to ADULT usually takes place inside a special covering called a PUPA which, in the case of butterflies, is called a CHRYSALID. When the larva has finished feeding and growing, this pupal case grows round it, and in most cases the creature appears to be quite lifeless. It is far from dead, however, and nature is very busily engaged growing the wings and legs and making all the other remarkable changes that are necessary. When all these changes have been made, the fully grown insect will emerge from its tiny prison—perhaps in the following year, or perhaps in a few days' time. When this final stage is reached, the majority of insects are able to mate in order to produce eggs. That is one reason why nature gives most of them wings—their wings enable them to move about more easily and seek a mate for breeding. Of course, most of them do go on feeding, but the food they eat is not intended to make them grow. It is required only to supply fuel for flying and material for making the eggs. Very often, though not always, the fully grown insect feeds on quite different food from what it needed when it was a larva. Caterpillars, for instance, usually feed on the leaves of plants, but the moths and butterflies into which they turn sip only the sweet nectar from the summer flowers or the sugary juices of ripe fruit. Do you notice the interesting comparison that can be made between flowers and butterflies? They are both intended by nature to produce offspring—seeds in the case of flowers, eggs in the case of butterflies. In a way, the beautiful butterfly *is* a sort of flower! If you have read the book *Bambi* by Felix Salten you will

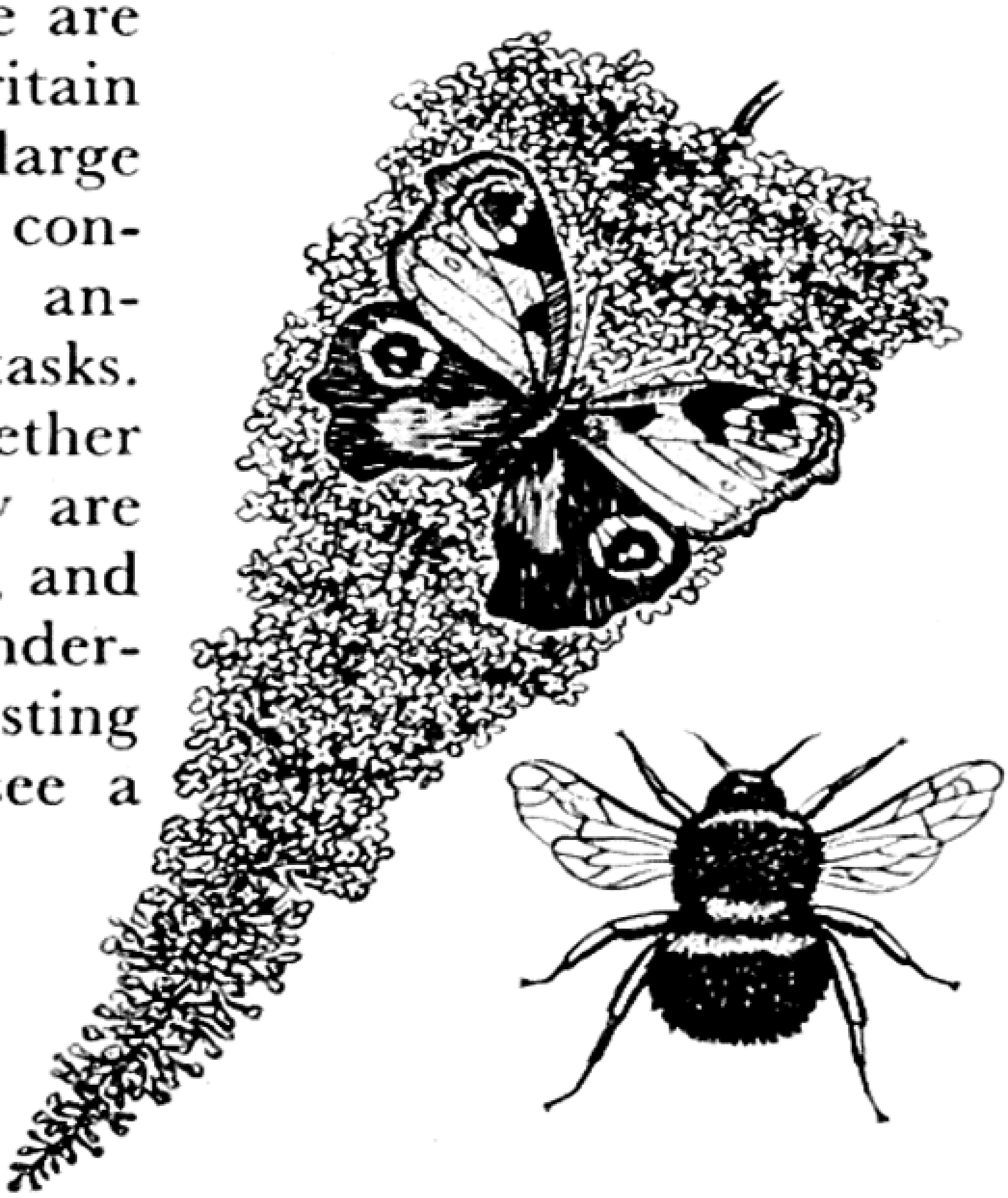


These three pictures show a fully grown butterfly emerging from its pupa.

remember that when the young fawn saw butterflies in the meadow for the first time, he thought they were flowers without stalks! He was nearer to the truth than he guessed!

INSECTS THAT LIVE IN BIG FAMILIES

Most insects that we see around us live lives of their own. They do not bother to help one another in any way. Each one looks after itself and there is no home life at all. But there are some insects in Britain that live together in large groups, and these are constantly helping one another with various tasks. Insects which live together in nests in this way are called SOCIAL INSECTS, and a study of their wonderful ways is very interesting indeed. You may see a bumble-bee and a peacock butterfly feeding side by side on the same flower. The butterfly is feeding for itself alone, but you may be sure that the bee is not only having its own meal; it is also collecting nectar and pollen to carry home to the nest for feeding the young larvae or grubs. The bumble-bee is a social insect, you see,



Searching for food is a bigger task for bumble-bees than it is for butterflies. Can you give the reason?

and has to work for others as well as itself. Can you think of any others that work for one another in this way? There are only three more kinds in Britain—the ant, the wasp, and the honey-bee. The nests of these insects are full of busy creatures all working together for the benefit of the *community*.

THE BUMBLE-BEE AND THE WASP

Let us look first of all at the life stories of bumble-bees and wasps. You have perhaps noticed that there are not many of these insects about in the early spring, but that their numbers increase very rapidly as the summer advances. Why is this? It is because almost all those that you saw in the previous summer died long before the winter began. The only members of the nest that did not die were a few **QUEEN BEES** from the bumble-bees' nest, and a few **QUEEN WASPS** from the wasps' nest. When winter approached all the others died, and these queens, after being mated with a male of their kind, flew off to find a resting place for the winter—perhaps under the loose bark of an old tree or maybe beneath a pile of dead leaves—so that they could be well protected from frost and snow during their long winter's sleep.

If you keep a good look out in the early spring, you are sure to see some of these fat queens flying about the hedgerows looking for some suitable place in which to start a new nest for the year. They look much larger than ordinary bumble-bees and wasps, and are curious creatures to watch at this time—seeking diligently in every nook and cranny for a hole in which to establish a home.

Let us suppose that we are watching a queen bumblebee at her task. When some satisfactory hole has been found she sets about making it bigger. The cavity she chooses is usually in the ground—perhaps it is the old nest of a mouse or part of a mole's tunnel—and the mother of the nest-to-be enlarges and shapes the hole she has found by carrying out thousands of grains of sand and tiny crumbs of soil. Inside this hole she begins to build her own nest, carrying in and weaving together tiny strands of moss and blades of grass, so that when it is finished her home looks rather like a bird's nest! This is surely a lonely task for such a tiny creature, but she goes untiringly about her work until the job is complete—pausing only to visit the young spring flowers from time to time in search of nectar and pollen.

When all is ready she begins to make her cells—little pots of wax and pollen about as big as small acorns. Into one of these she lays a number of eggs and seals it up. These eggs soon hatch out and the little grubs begin to feed on the pollen of which their cell is partly made. The mother bee continues to make more cells and to lay more eggs, only coming out of the nest to gather fresh pollen as it is needed by the growing larvae. After about three weeks her lonely task becomes easier, because by this time the first of her children are ready to fly, and they set to work immediately—bringing in more food, feeding the increasing number of grubs, and building more and more cells, so that the queen herself can spend all her time laying eggs. From this time onwards, the number of bees increases very quickly and the nest soon becomes a very flourishing concern.

You should notice carefully that the queen bumble-bee by whom the nest was begun is the mother of all the bees in it. She lays all the eggs from which the larvae hatch out, and her numerous daughter bees are what we call WORKERS. They can't be mated with a male bee, and for this reason they are unable to start new homes of their own. They will spend all their lives working for the nest in which they were born, and by the beginning of winter they will all be dead. You learnt on page 114 that most insects are able to breed when they reach the adult stage of their lives. The worker bumble-bees are exceptions to this general rule, and so are the workers of all the other social insects—wasps, ants, and honey-bees as well. These workers are really female insects, but their egg-laying organs are not fully developed. Only the queens can mate with a male insect of their own kind, and they are called queens in order to distinguish them from the workers. They are queens only in name, however, for they do not really rule the colony of insects in which they live. Indeed, they are far too busy laying eggs to be real rulers. Perhaps the queen's importance to the life of the colony earns her this distinguished name. For important she certainly is. Remember that she is the mother of all the insects in the nest. Sometimes there are several laying queens in a colony of ants, but there is rarely more than one queen in a nest of bees or wasps.

As the season advances fewer workers are produced, but nature is well aware that she must provide for the future of the bumble-bee race, and towards the end of the summer a number of young queens and a number of male bees are produced. These male and female bees fly out of the nest in the autumn and pair with one another. The queens—who are now said to be *fertilized* and able to lay eggs—seek about for some suitable crannies in which they can pass the winter. Quite a number of new queens come from each nest, just as one single plant always produces a large number of seeds. You may imagine that the number of bumble-bee nests would increase each year for this reason; but many of the queens will die from cold, or will get snapped up by some bird or other foe. In order to be fairly sure of at least one successful surviver, nature produces several queens from every nest. It is wonderful to think that these new queens already contain within them the eggs from which *all next year's bumble-bees* will be born! Yet so it is.

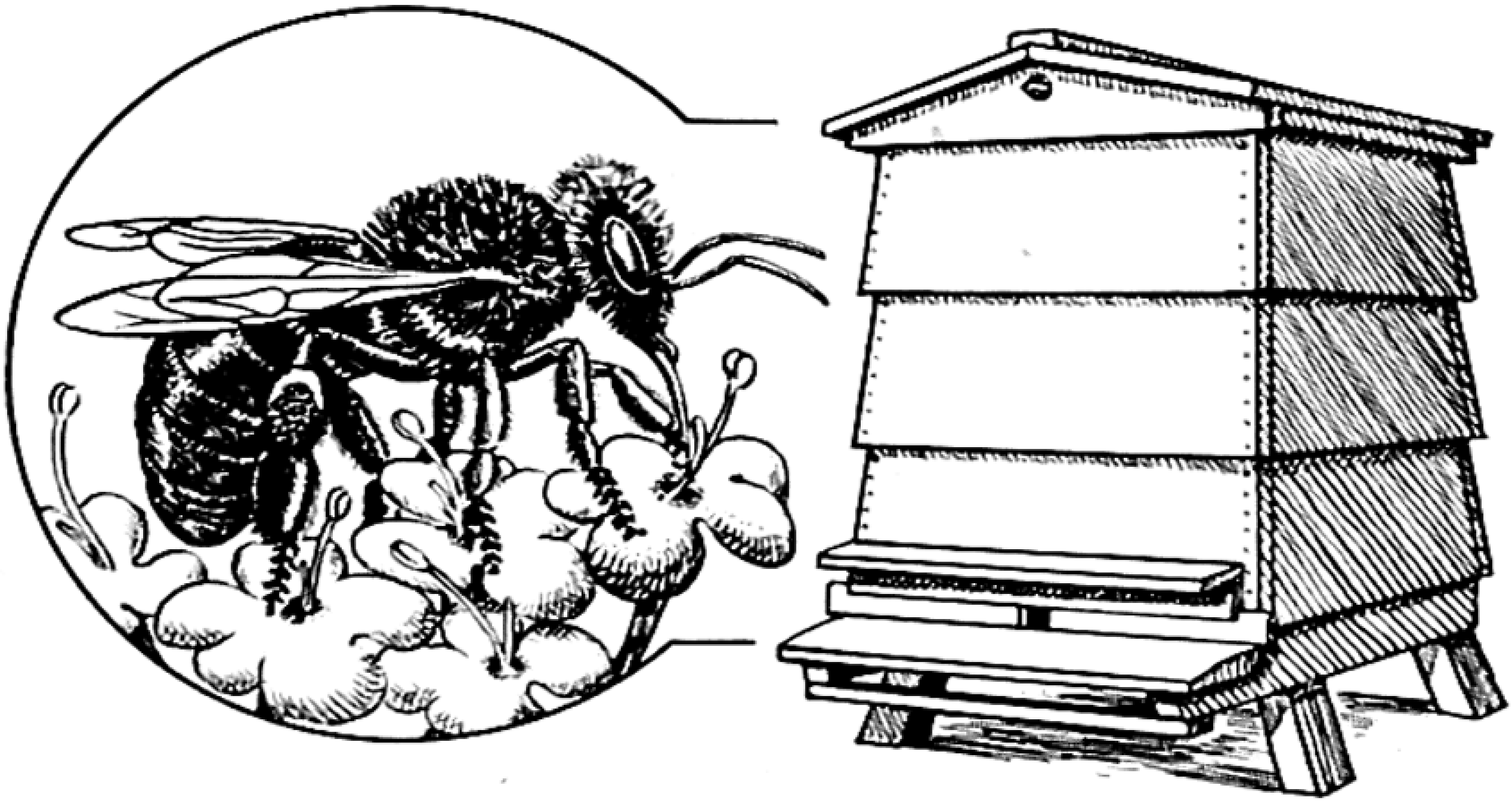
The queen wasp comes out of her winter quarters a little later in the year than the queen bumble-bee, and the cells that she builds for her eggs are made, not from wax and pollen, but from paper. The queen makes this paper herself! She chews up fragments of dead wood so as to make a sticky paste, and each 'mouthful' of this paste is used for building her nursery 'cradles' or cells. These cells are unlike those we find in a bumble-bee's nest; each one has six sides, and they are arranged together in the form of a 'comb' rather like the honeycomb shown on page 124. Also, instead of feeding the young grubs on pollen and nectar, the wasp feeds them on flies. When the first worker wasps are ready to fly, they help the queen with the work of building cells and foraging for food, and the colony grows apace as the weeks go by. Wasps are very valuable to us because of the large number of flies that they kill for their young ones, and you should not destroy their nests unless they are uncomfortably near to your home. Did you realize that wasps were never to be seen collecting pollen? Occasionally they will visit a flower to take a sip of nectar; but they usually prefer some juicy fruit like a soft plum or a ripe blackberry for their own food. Most of their time, however, is spent hunting flies for the young wasp grubs back at home.

THE HONEY-BEE

The life stories of both the ant and the honey-bee are very similar to the life stories of the bumble-bee and the wasp. There is, however, one very important difference. The worker ants and the worker honey-bees *do not die when autumn comes*—they spend the whole winter inside the nest, rarely coming out into the open. During the long days of summer these workers not only collect food for the young larvae, they also gather in enough stores for use in the hive during the winter. In the case of the honey-bee this winter food consists mostly of honey, which is stored both in the cells that have been used as 'cradles,' and also in countless other similar cells that have been made specially for the purpose.

Usually the industrious honey-bee collects so much surplus honey that it is quite possible to take some away for our own use. Indeed, this is one reason why so many people keep bees in gardens and orchards.

In order to keep honey-bees, we provide them with a special hive in which to live, and, of course, when we keep bees in hives we can gather the honey without going to the trouble of looking for wild nests. If we gathered honey from wild nests we should not only have the trouble of searching for the nests, we should also need to destroy a good many of the bees, and the nests themselves would be severely damaged. A modern hive, however, enables us to collect honey without doing any damage at all—either to the bees or to their homes.

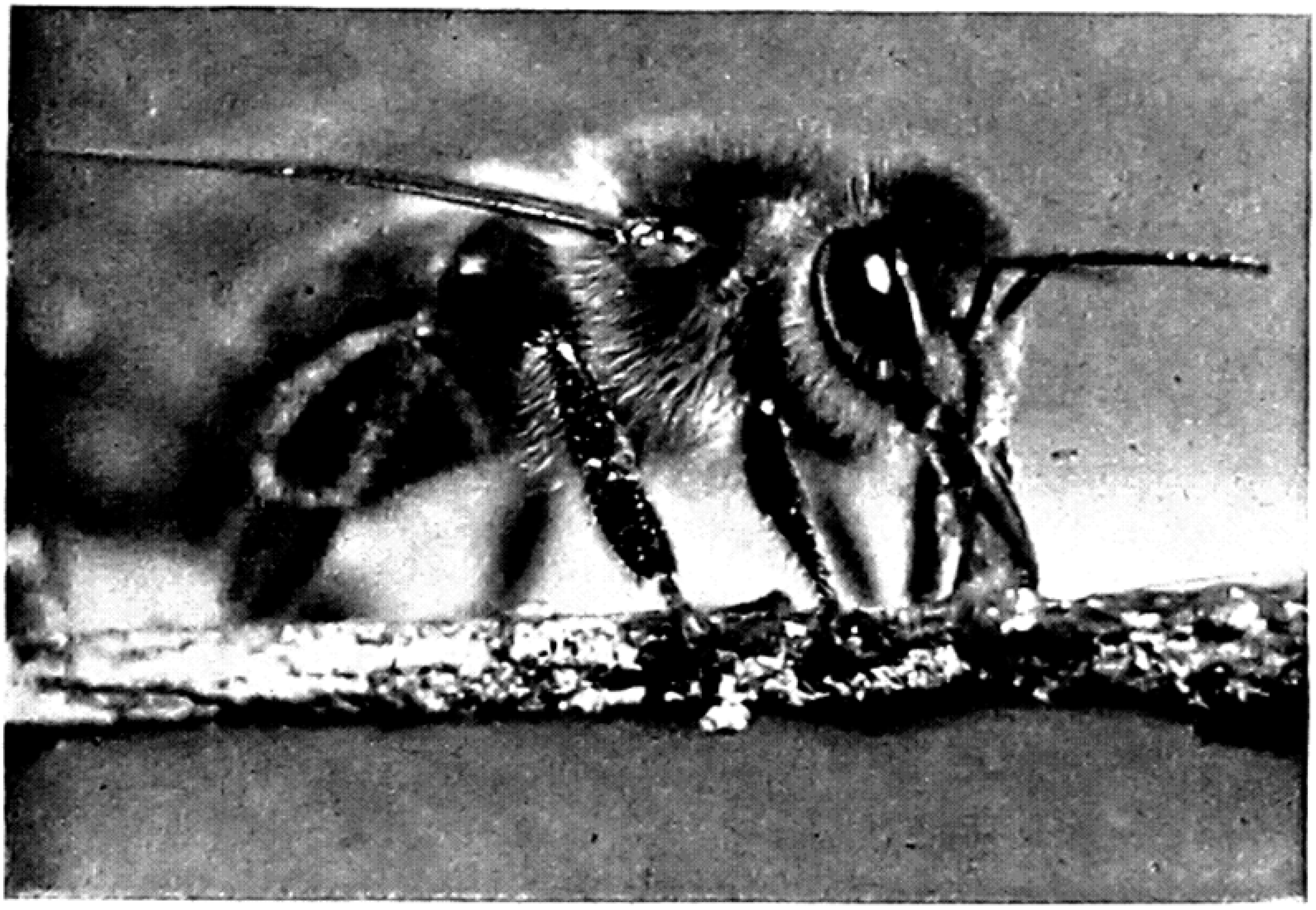


Most insects live *solitary* lives, but honey-bees are social creatures. They live together in large numbers.

You may well wonder what happens to the bees in winter if all their stored honey is taken away. Surely they will die of starvation? Many of them would no doubt die for lack of food, but the wise beekeeper is aware of this, and he always takes care to leave them with sufficient stores for the long winter months. He leaves a large amount of honey in the hive; and, in addition, he supplies his bees with sugar syrup in return for the honey he takes away. Fortunately the bees usually store far more honey than they are likely to need, so that the beekeeper does not have to replace *all* the 'stolen' honey with sugar syrup.

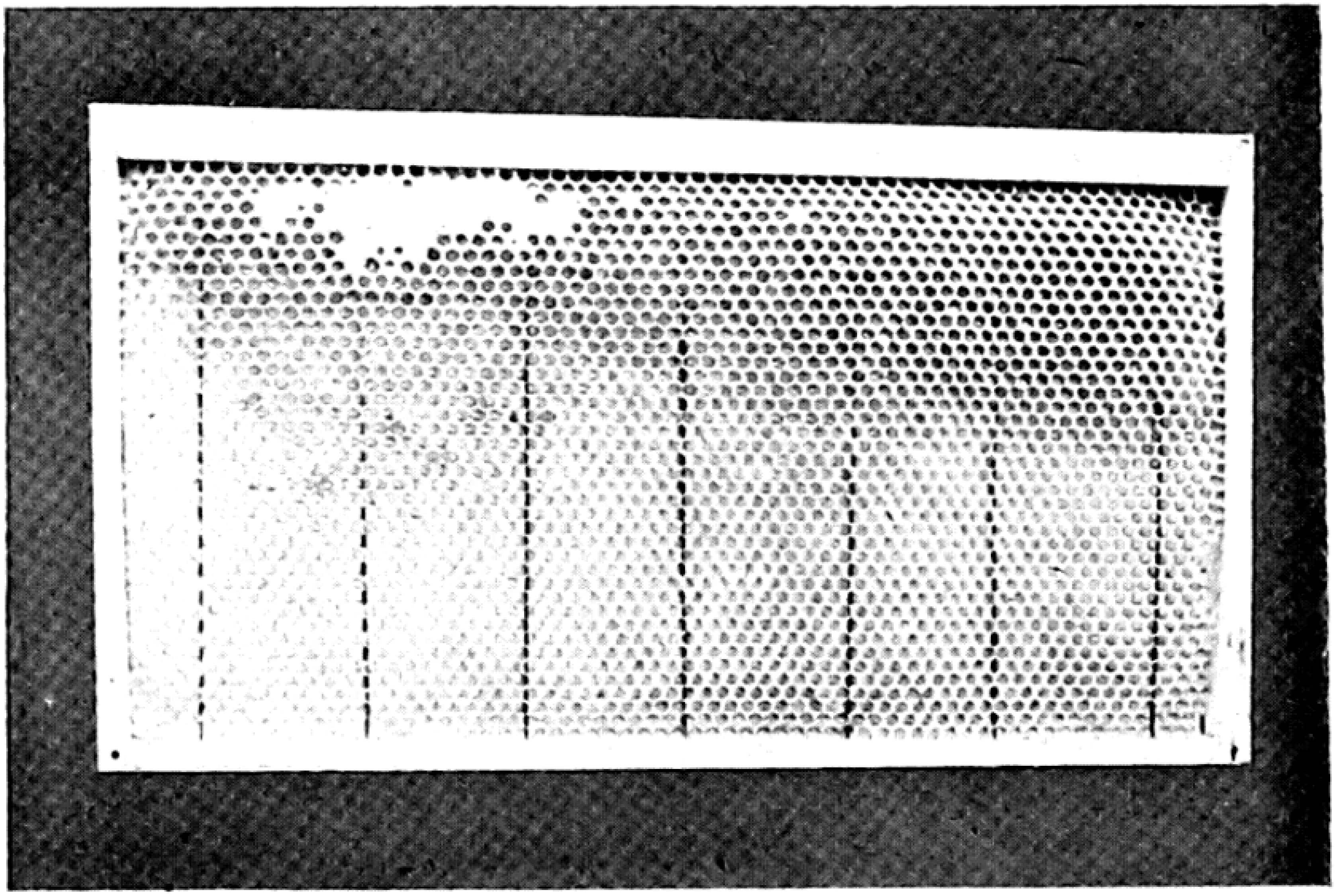
You may wonder also why we do not put bumble-bees in hives so as to get honey from them too. In the first place, the bumble-bee does not need to store honey for the winter because only the queen lives on, and she goes to sleep. And secondly, even if the bumble-bees did collect winter stores, there would never be a great quantity, because there are only three or four hundred bumble-bees in one nest. Do you know how many honey-bees there are in one hive? There may be forty thousand or more! Such a large number of bees can collect a great deal of honey during the summer months, but you must remember that it takes a lot of nectar to make a small quantity of honey, and because each worker bee can carry only one tiny drop of nectar at a time, very many bee journeys are necessary in order to provide even one pound of honey. However, the honey-bee is a very industrious insect indeed, and sometimes a beekeeper is able to take a whole hundredweight of honey from one hive at the end of the summer! This is, of course, exceptional, but it is quite common for a hive of bees to yield forty or fifty pounds of honey in one season. It is wonderful to think that this great quantity of sugar—for that is what honey mostly is—can be gathered from flowers in tiny sips. No wonder we speak of the *busy* bee!

If we take a look inside a beehive we shall surely be astonished at the sight of so many bees all living together. The inside of the home is made up almost entirely of cells, nearly all of which are six-sided and look rather like the cells in a wasps' nest. They are arranged together in the form of a 'comb,' but instead of being made of paper they are made of beeswax; and whereas the cells in a wasps' nest hang mouth downwards those in the beehive are arranged almost horizontally. Why does the honey-bee build its combs



The honey-bees' nest contains thousands of worker bees like this one. Theirs is a life of labour.

so that the open ends of the cells face sideways in this way? Remember that the wasp uses its cells for one purpose only—the rearing of its young. But the cells in a beehive are used not only as 'cradles,' they are used also for storing honey, and it would be quite impossible to pack the liquid honey into cells hanging mouth downwards. So the bee fixes them in a more or less horizontal position. They are not *quite* horizontal. If you look at them carefully you will see that they slant upwards very slightly. This upward tilt makes the storing of honey easier still, and there is no risk of any of it running down the sides of the combs.



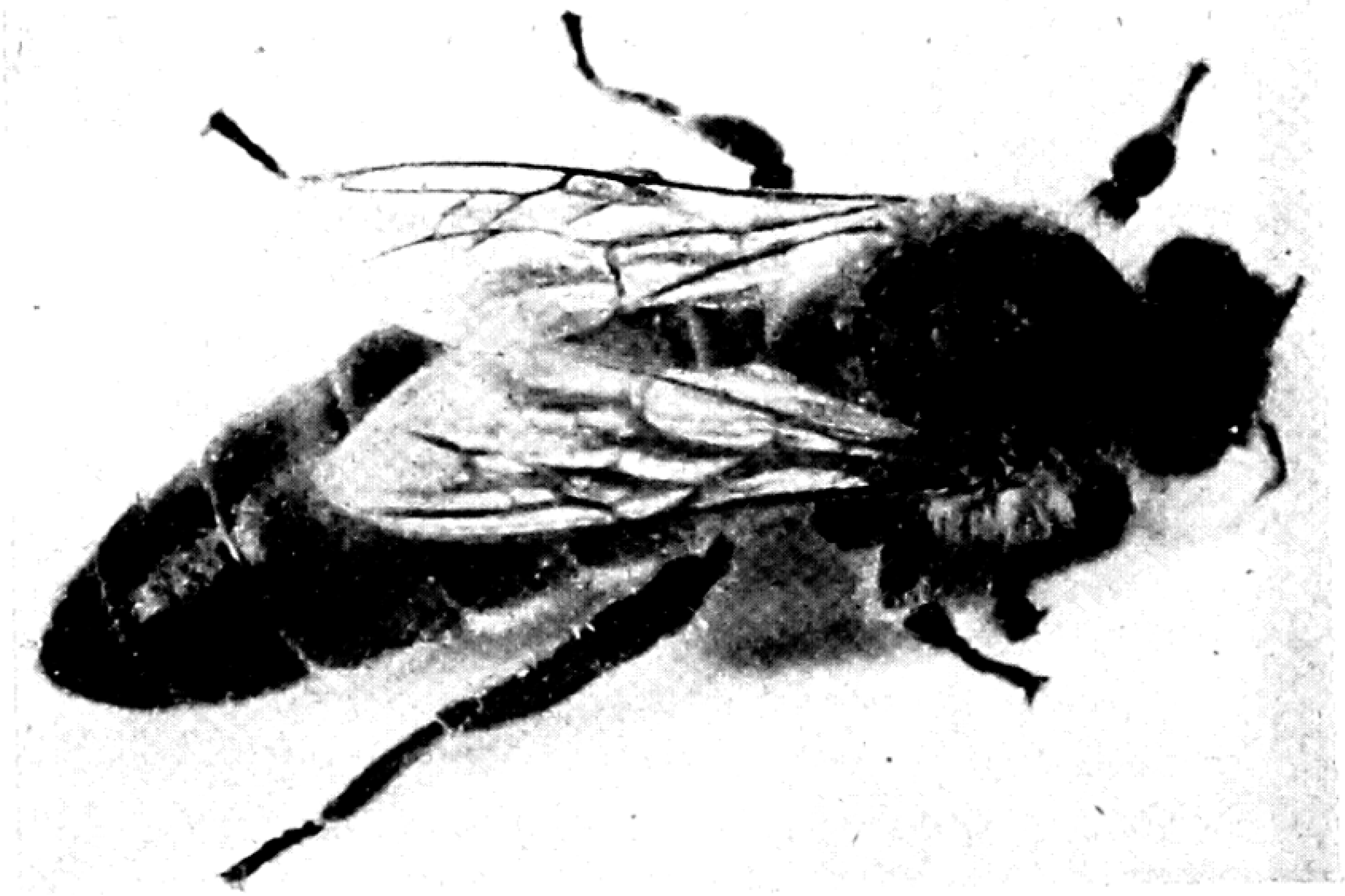
Honeycomb is made up of cells. In the summer many of these cells are used as 'cradles.' What do they contain during the winter?

Most of the many bees in the hive will be found on the combs. If we lift out one 'frame' or comb from the hive we shall be able to see the bees more clearly. What are they all doing? There are many different tasks to be performed in the hive. Some bees may be seen building new cells, others are perhaps busy unloading honey or pollen, and on a warm day you may notice that some of them are fanning their wings very rapidly indeed. These bees are the ventilators of the hive. There were fans to be found in nature's homes, you see, long before the invention of the electric fan! These are only a few of the many duties that have to be performed, and it is quite certain that most of the bees in the hive are busily engaged.

QUEENS AND DRONES

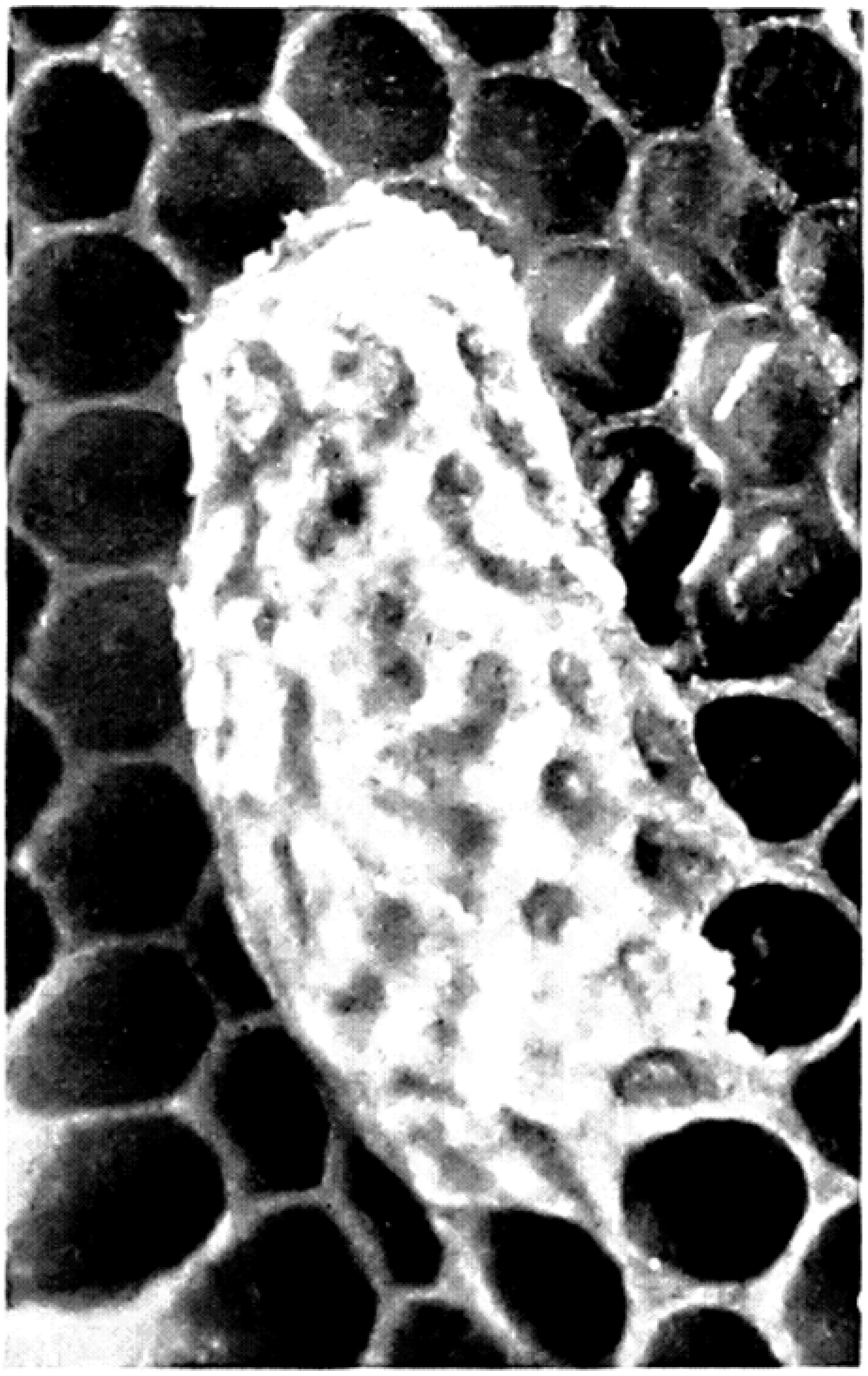
What about the queen bee? Can we see her too? She is much longer than a worker bee, but it is often a very difficult task to 'spot' her among so many thousands of workers. You may be sure, however, that she is somewhere in the hive. During the spring and summer she is kept very busy indeed laying eggs in the countless cells. In the height of the summer she may lay as many as two thousand, or even three thousand, eggs in one day! If she has been queen of the colony for a year or more, all the bees in the hive will have come from eggs that she has laid. *She is the mother of them all!* There is no other creature in the whole world, except perhaps the queen ant, that is the mother of so many daughters. Fancy having a family of some forty or fifty thousand living children! It is indeed fortunate for her that they can look after one another, keep the house clean, and bring in all the food. Remember that most of the bees in the hive are workers that do not have 'families' of their own.

Does the queen bee ever produce daughters that can breed and lay eggs, just as she does herself? And what about sons? Do any of her eggs hatch out into grubs that turn into male bees? A little thought will enable you to give the answer yourself. The time is sure to come when the queen is too old to go on laying eggs, and if no new queen and male bees were produced the bee race would soon cease to exist. In order to keep the race alive, each colony of honey-bees 'raises' a number of new queens each year—usually in the spring and early summer—and, in addition, a number of male bees—called DRONES—are produced. It is necessary to have the drones, because the queen cannot produce any worker bees until she has been mated with a drone. You can quite easily see the drones in the hive as they are much bigger



Notice the long body of this queen honey-bee. Can you guess why she has to have such a long abdomen?

than the active workers. Drones are very lazy bees indeed. They never do any work in the hive, and they never bring nectar or pollen into the hive. Indeed, they are usually too lazy even to feed themselves, and they allow the workers to offer them sips of food!



The birthplace of a queen honey-bee. Why does it need to be so big? Notice that some of the worker cells contain honey.

Special cells are made by the workers for these important offspring—bigger cells than those from which the worker bees emerge. Both the queens and the drones are bigger bees than the workers, and the ordinary cells of the hive are not big enough to contain them. Indeed, the queen cells are so big that they will not fit among the other cells at all, so they have to be built either on the edge, or on the 'face,' of a comb of ordinary cells. As you see from the picture, the queen cell looks rather like a long, tapering thimble.

WHAT IS A SWARM?

The beekeeper has to keep a careful look out for these queen cells and, as a general rule, he removes them when they appear. If he allowed a new queen to mature in her 'cradle cell' it is very likely that nature would take her course and there would be a SWARM. That is what happens in a 'wild' nest when a new queen arrives on the scene. The original queen flies away to a new home, and along with her go several thousands of her workers. This is a brave venture, because the bees in this swarm will never return to the place of their birth; they are adventurous pioneers who will found a new colony somewhere else, and the only 'baggage' they take with them is a good meal of honey with which they gorge themselves before they start their journey. Most of the workers, however, stay behind in the old home, and the new queen takes on the task of laying eggs. The result of the swarm is that there are now two nests of bees where before there was only one. It is important for us to remember that the honey-bee—even though it lives in a hive—is still a wild insect and would, if left alone, be perfectly able to look after itself and to start new colonies by swarming.

There are many honey-bee nests in Britain that are not in hives at all—such wild nest may be found in some cottage roof, or perhaps in the heart of some ancient tree. The 'wild honey' which, we are told, was part of the diet of John the Baptist, would be honey that he took from such nests.

THINGS TO DO

(1) Imagine you are one of the worker bees flying out with a swarm. Write the story of your adventure. Mention the good feed of honey, the 'scouts' that go out to look for a suitable place, the weather, and the work that has to be done upon arrival at the new home. Entitle the story 'An Adventurous Flight.'

(2) Use single sentences to answer the following questions:

- (*a*) Why is the tropical mosquito a pest?
- (*b*) Into what three parts is an insect's body divided?
- (*c*) Why don't we call the spider an insect?
- (*d*) What are the four stages in an insect's life?
- (*e*) In what two ways is a butterfly like a flower?
- (*f*) What kind of an insect is the common wasp or the honey-bee?
- (*g*) What would you say if in the winter someone asked you where all next year's bumble-bees were to be found?
- (*h*) Why are honey-bee workers able to live through the winter?
- (*i*) What is the use of a drone bee?
- (*j*) Where does honey come from?

(3) Some flowers are visited more often than others by bees and wasps, and you are going to try to find out some of their favourites. Use a double page of your Country Book on which to make your records, and across the top

put the title: 'Flowers visited by Bees, Wasps, Butterflies, and Moths.' Whenever you see any one of these insects gathering food, write down the name of the flower, and alongside it put H, B, W, By, or M to show which insect you saw. If you see the same flower visited *on another occasion*, just add the insect's initial. After a time your record will begin to look like this:

Marigold	H, H, B, H, H, W, By.
Phlox	M, By.
Hollyhock	B, B, B, W, H, B, B.
Dandelion	H, H.

At the end of a month you will be able to tell from your record which flowers near your home are the favourites of each insect, and you will be able to write a short paragraph entitled 'Flowers that Insects Visit.' Try to find out which flowers are *not* visited by any of these four insects.

9

Country Hobbies

SOME LIVING CREATURES AT CLOSE QUARTERS

When that the monethe of May
Is comen and that I hear the fowles synge,
And that the floures gynnen for to sprynge.
Farewell my boke and my devocion.

CHAUCER.

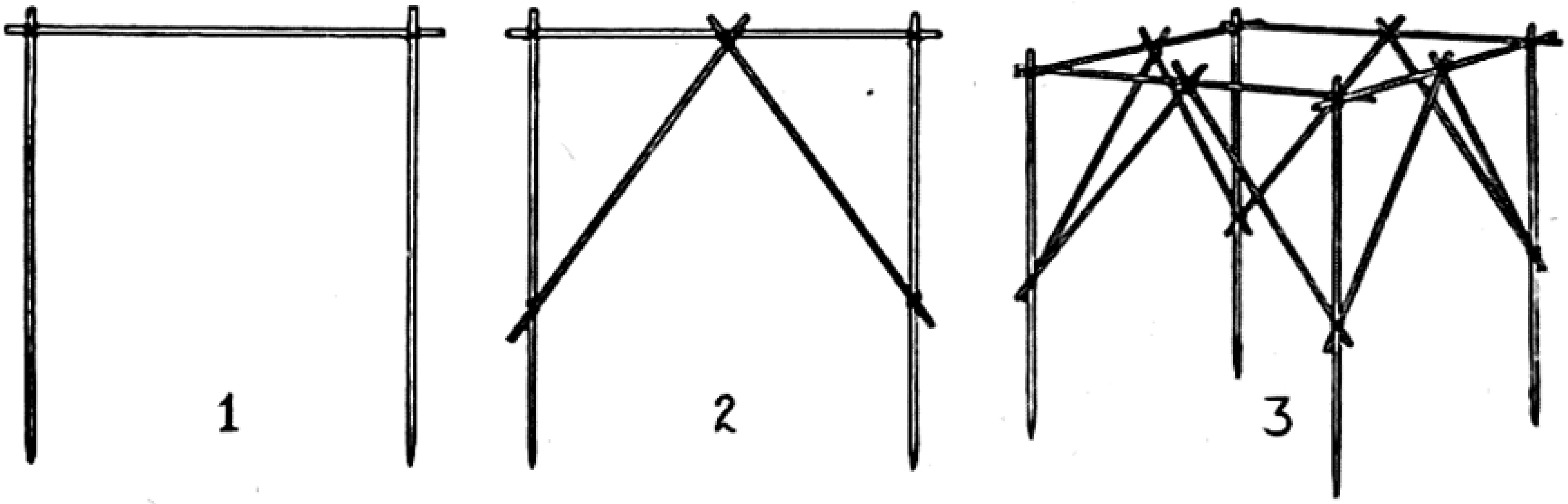
There is cool green grass there, where men may lie at rest,
And the thrushes are in song there, fluting from the nest.

JOHN MASEFIELD.

IT is quite easy to study any wild plant when once you have found it, but birds and insects do not allow you to get near to them so easily, and you need to be much more of a hunter in order to watch them closely. In former days it was the custom to kill wild creatures for the purpose of close examination, and many people kept collections of dead birds and butterflies and so on. But this is not at all necessary, and it is a great deal more interesting to watch the living things going about their daily lives. In this chapter you will learn some ways of doing this.

HIDES AND TABLES FOR BIRDS

When once you have learnt to recognize a few of the common birds, you can take a closer look at them by using a small shelter called a bird-hide. You will need to do this either in the nesting season or in the winter, because these are the only times of the year when you can be sure that the birds you wish to look at will keep on returning to the same place. Let us begin by watching birds at their nests. Your first task is to find a nest that is quite low down, so that you can easily see into it—a blackbird's nest in a low bush or a lark's nest in a tuft of grass are in suitable positions. When the birds have laid all their eggs and are beginning to 'sit' them, you can prepare your hide. This needs to be quite light, so that you can carry it easily to the field where your chosen nest is situated.

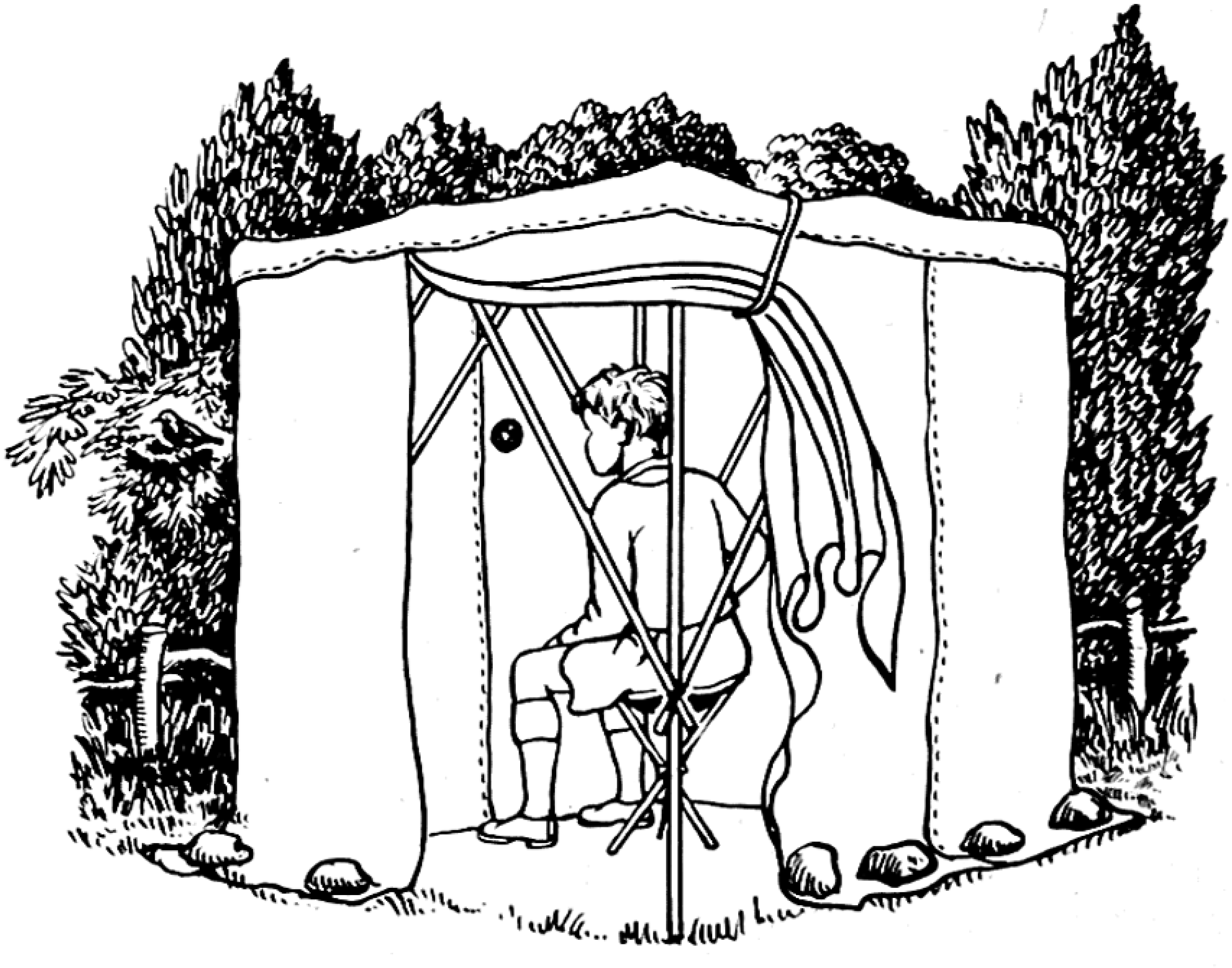


These three diagrams show you how to build the cane framework for your 'hide.'

To make the hide you will need twelve strong canes, each of which is about five or six feet long, together with a ball of strong thin string. Take three of the canes to begin with, and using two as uprights bind the third one to them with string so that you have a miniature set of goal-posts (Fig. 1). You must use plenty of string for the binding, and see that you keep it tight. Now split one of your canes lengthwise into two pieces and fix these firmly on to your 'goal-posts,' as shown in the diagram (Fig. 2).

One side of your hide is now complete. When the whole framework is finished it will look rather like the skeleton of a square table (Fig. 3), and each side will have the same appearance. The bottom of each leg should be sharpened to a point so that the hide can be pushed firmly into the ground. You will now need plenty of clean sacking with which to cover the framework. Fasten the sacking (rough sewing with the farmer's sacking needle will do the job) across the top and around all four sides, so that your hide looks like a square, flat-topped tent. There must be enough sacking to come well below the bottom of the framework, so that there is plenty of 'slack' material on the ground when the hide is set up. This will prevent the birds from seeing your feet as you move about inside. You should leave a flap so that you can enter easily; and in order to have a good view of the birds, cut a round two-inch hole in the sacking on one side of your 'tent.' You will need to rig up a seat of some kind inside so that you can watch the birds in comfort, and you must fix the hole so that you can see through it when you are seated.

You are now ready to place the hide in position. If you are watching fairly bold birds like the blackbird or song thrush you can plant your home-made tent close up to the nest right away without any fear of disturbing the birds unduly. You will, however, need to leave it unoccupied for a day or two so that the timid creatures can become accustomed to its appearance. Birds such as the lark or the lapwing are more easily alarmed, and you must adopt a different plan. On the first day erect the hide some fifty yards from the nest. Push the legs firmly into the soil and place some heavy stones on the slack part of the sacking at the bottom. Your 'tent' has no protection against wind in the open field, and the stones will prevent it from being blown over. Each day, move the hide ten or fifteen yards nearer to the nest, until it is within about three yards of it. You must now leave it entirely alone for a few days.[1]



You can easily watch birds at close quarters if you make a simple 'hide.' The flap needs to be closed, of course, when you are actually watching.

When you intend to remain in the hide to watch the birds, it is best to approach it with *two* friends. After you have got comfortably settled, they will leave you inside, and the birds, seeing them walk away, will feel quite sure that there is no one about. After this you must make no noise at all, and it is important not to touch the top or side of the hide with your head or elbows. At last, you are the invisible one!—and you must take care not to let the birds see your eye through the peep-hole. They are quite unaware of your presence and will go about their business quite freely—and for the first time in your life you will experience the joy of watching wild birds at close quarters. After this, you will not wish to take their eggs; in some strange way you will feel a real interest in the success of their family-raising adventure, and you will be just as concerned as the birds themselves to see the young nestlings brought up safe and sound. It is important not to come out of the hide until your friends return, as your sudden appearance would most certainly alarm the birds. Arrange for your companions to return in a quarter of an hour—or more if you think you can remain quite still for so long!—and one of them can now take his turn at watching.

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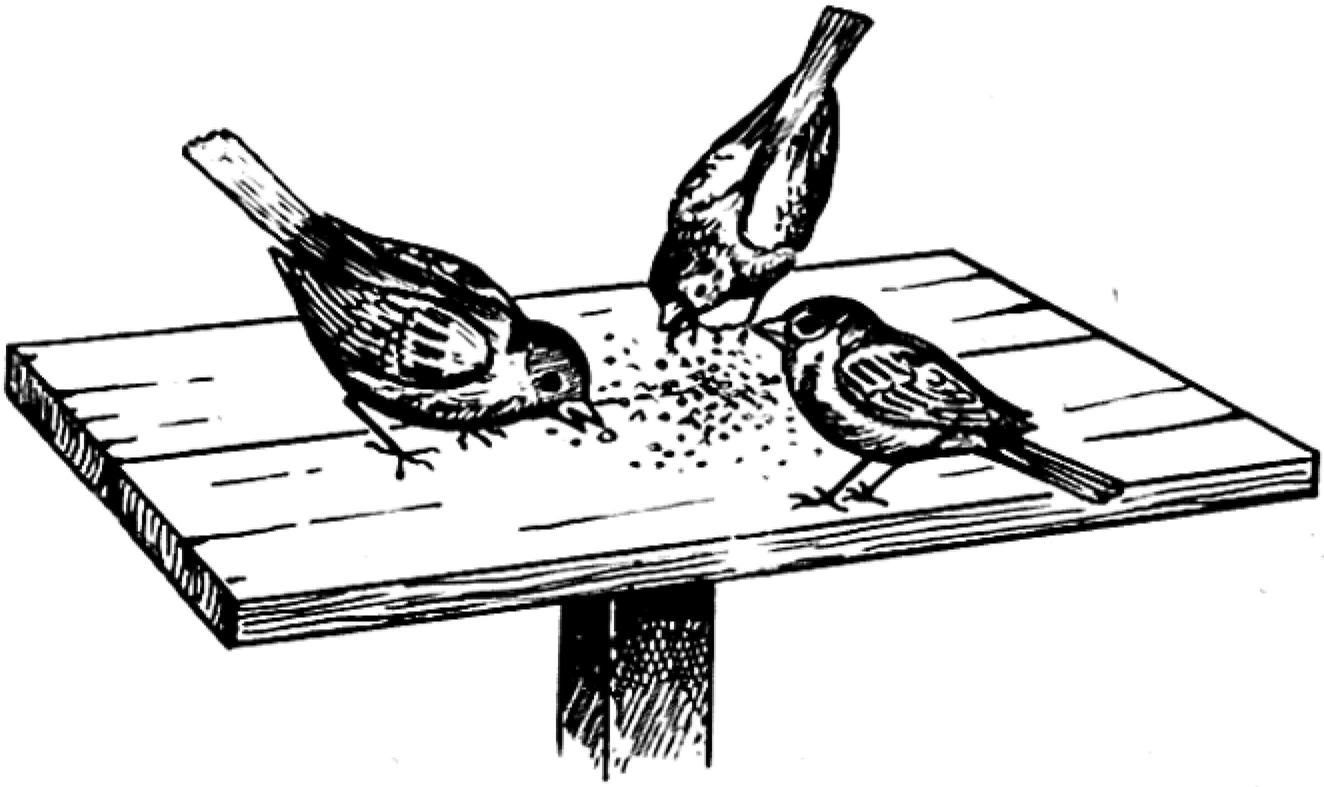
[1] If your birds are in a very windy place, you should fasten a tent 'guy' rope to the top of each upright, so as to secure the hide more firmly.

If you wish to begin watching birds in the autumn and winter, you will need to attract them to a feeding table. Birds will always come for food in the winter—and *water* if it is frosty—and you can either put the table near to a window, or, better still, you can fix your hide near to the table itself. In this way you will be able to watch all sorts of different birds as they come to feed.

The simpler the table, the better. Indeed, a strong post—fixed firmly into the ground—with a large board screwed or nailed firmly on to it is the best of all; and it is the simplest to make. Choose a place that is away from fences or buildings, so that the birds are not in fear of cats coming upon them unawares, and dig a hole for the post so that you can fix it really firmly. The top should be about 3 ft. 6 in. from the ground. A very high table is no use, as you can't see what is going on. On the table place a container for water. Birds are often afraid of glass or shiny pottery, and many kinds are easily scared by water containers that move about when they perch on them to drink. The best drinking trough for your table is a heavy piece of stone that has been hollowed out to hold water. Remember that birds suffer terribly from thirst during a long frost, so do not allow your water supply on the bird table to freeze up. Renew it each morning, and several times during the day if necessary. In this way the birds will get to know where they can find a drink, and you will attract many unusual visitors.



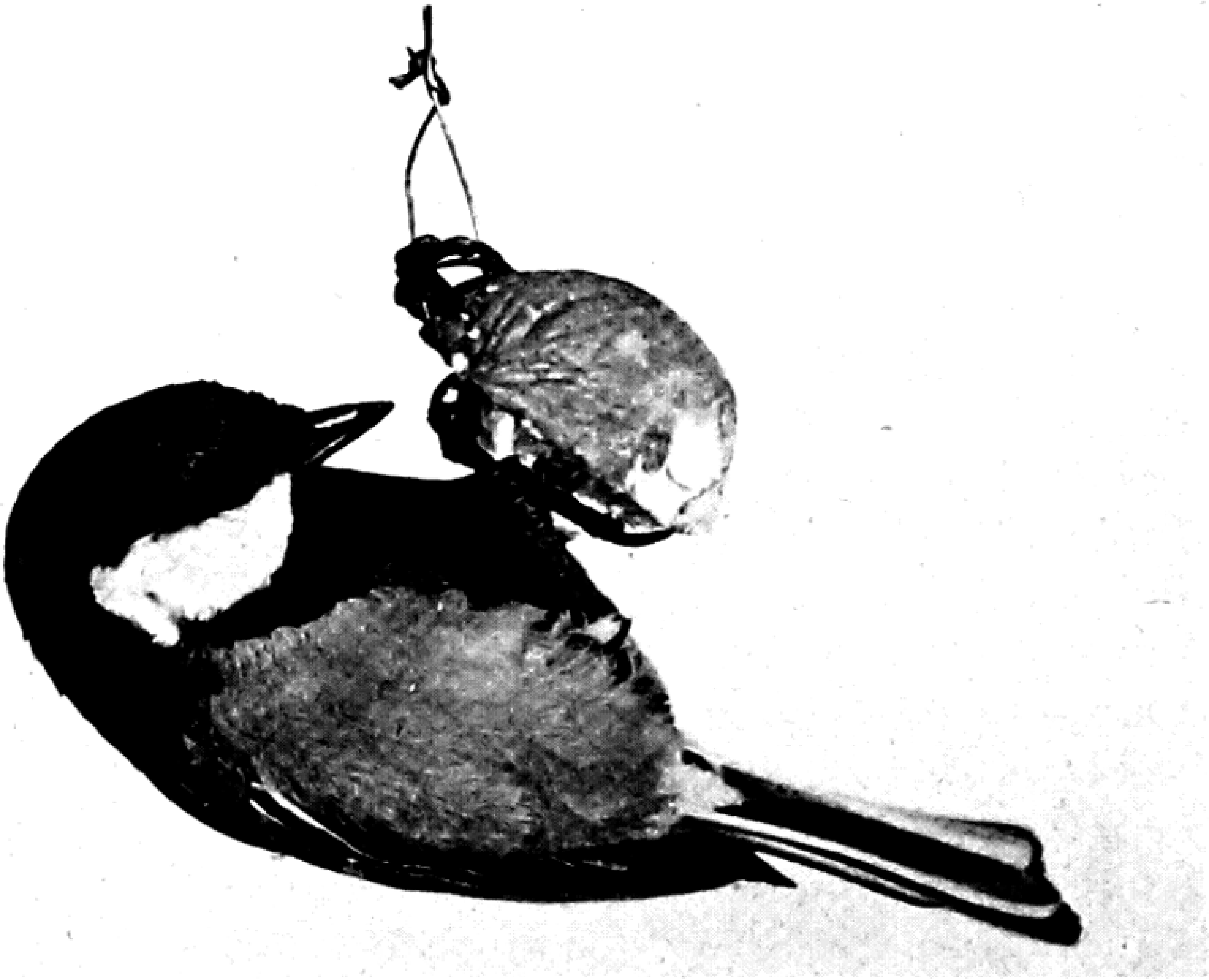
Birds will come to your table for food both in the winter and also when they are feeding their young.

What about the food you give them? Wild seeds of all sorts can be collected during the autumn, and these are always much appreciated in the winter, especially by the various finches. If you are able, collect a large bagful of such seeds, and include the long 'seed stems' of the plantain. Cones from the woods contain many seeds, and you should get a bagful of these. Make sure, however, that they are sufficiently open for the birds to be able to get at the seeds inside. If you wish to watch the tits performing their acrobatic tricks, you should tie some cones or nuts to pieces of string and suspend them from the edge of the table. The plantain stalks, too, should be fastened with string into small bunches and secured to the table top, otherwise they will be carried away.

Plantain heads make good bird seed.

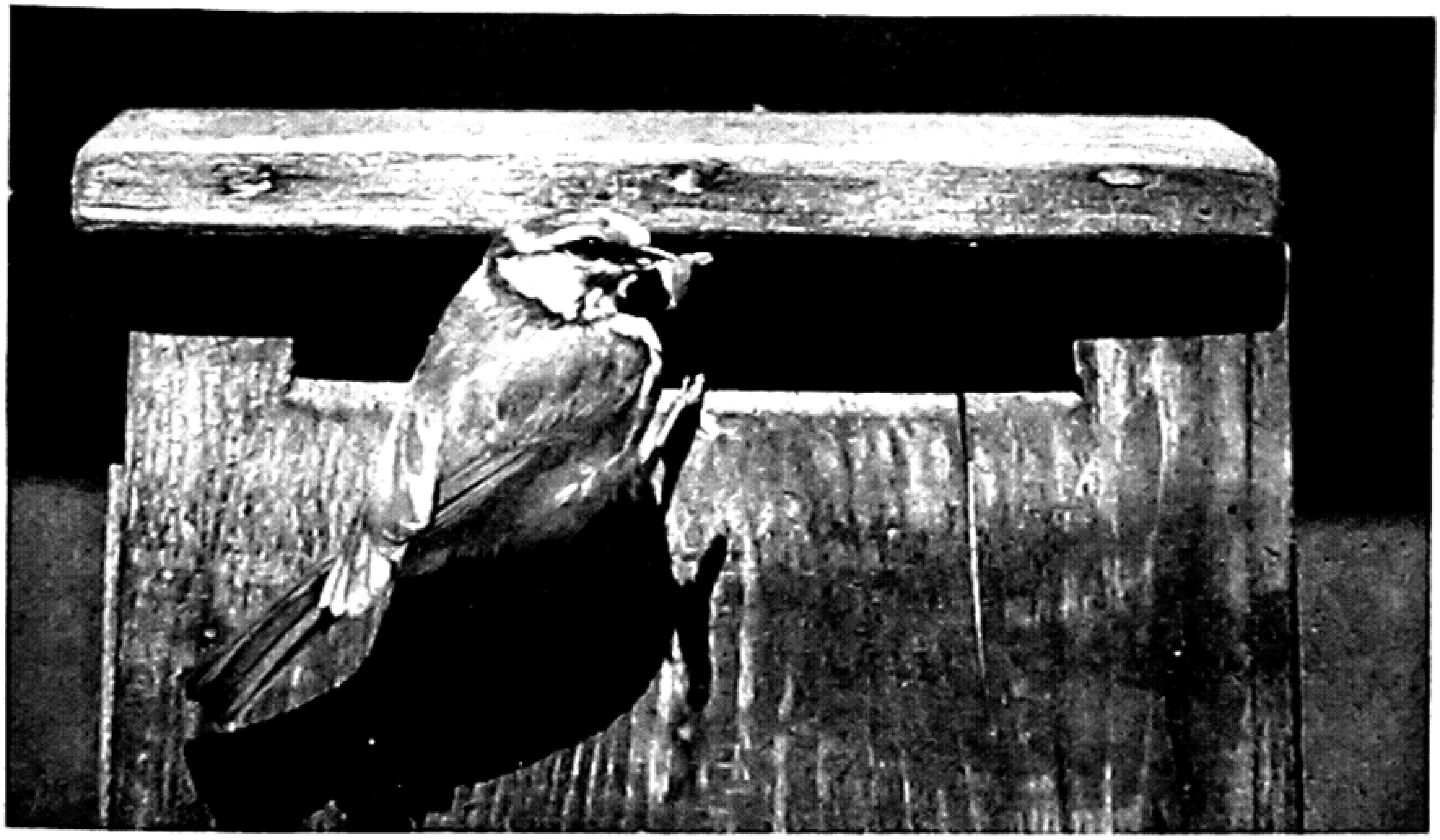
From the kitchen, you will be able to get many scraps. Crumbs brushed from the table, cheese rind, bacon rind, bones from the meat ration, fish heads, and so on. Half a coco-nut, too, is always a meeting place for the tits, and you can either place it on the table top or hang it from the edge on the end of a piece of string.

Whatever diet you choose for your visitors, the food should be put on the table at regular hours. Early morning and mid afternoon are the best times, as these are the usual winter feeding times of many birds. If you keep to a regular time-table, the birds will get to know what you are doing and they will often assemble in the surrounding bushes and trees at the appointed times and wait for your appearance. If you erect a hide near to the bird table, you will need to be accompanied by two friends when you go out to replenish the food supplies. Instead of returning to the house or the school building with them, you remain in the hide and watch the birds.



A meal of walnut for a hungry great-tit. Feed the birds in hard weather and you will save many of them from starvation.

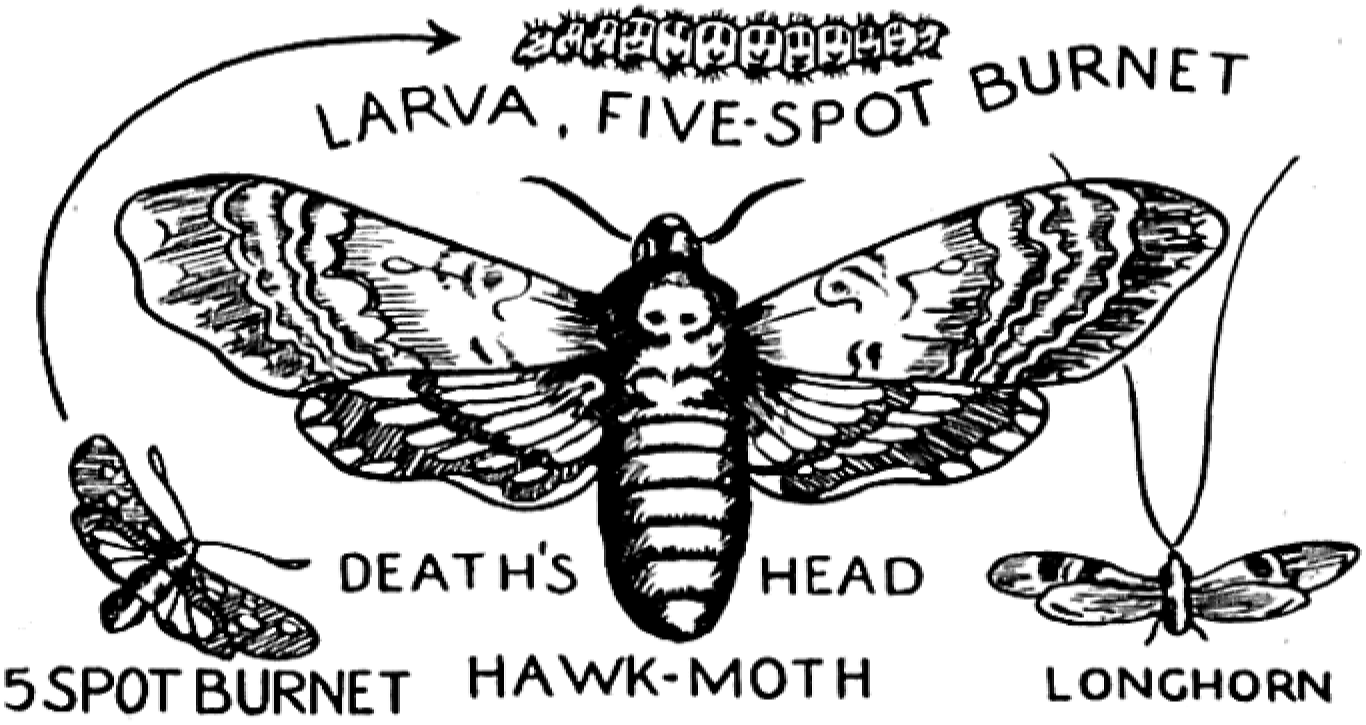
It is important for you to remember that you are not gaining pleasure for yourself alone when you feed birds in this way. The birds themselves benefit, and by keeping them alive during the hard season you are preserving them for their valuable work of pest destruction in the spring and summer. It is true that many birds do not eat flies and so on themselves, but most of them feed their young on insects of some kind, and if you have ever watched a pair of birds at work feeding their nestlings, you will realize what an enormous number of farm and garden pests are destroyed in this way. Notice one great advantage of having plenty of good hedges on farmland—there are always more birds where the hedges are good, because there is plenty of shelter for nesting. Most hedgerow birds are of great benefit to the farmer, and he encourages them to breed on his farm because they destroy his crop pests free of charge!



How can you tell that there is a brood of hungry youngsters inside the nesting-box of this blue-tit?

TWO WAYS OF EXPLORING THE MOTH WORLD

Moths, like butterflies, pass through their growing stage as caterpillars—and they pass through their pupal stage as chrysalids. Moth caterpillars and moth chrysalids can quite often be found; but we do not see so much of the adult moths. Why is this? By far the majority of them sleep in some hiding-place during the hours of daylight and live a life of mysterious activity during the hours of darkness. If we are to see them in all their wonderful variety, we shall need to carry out an exploration after sunset. Puss-moths, tiger-moths, hawk-moths, goat-moths, and shark-moths—there are very many of them, and if we are to see them we shall need to use some kind of lamp or torch.

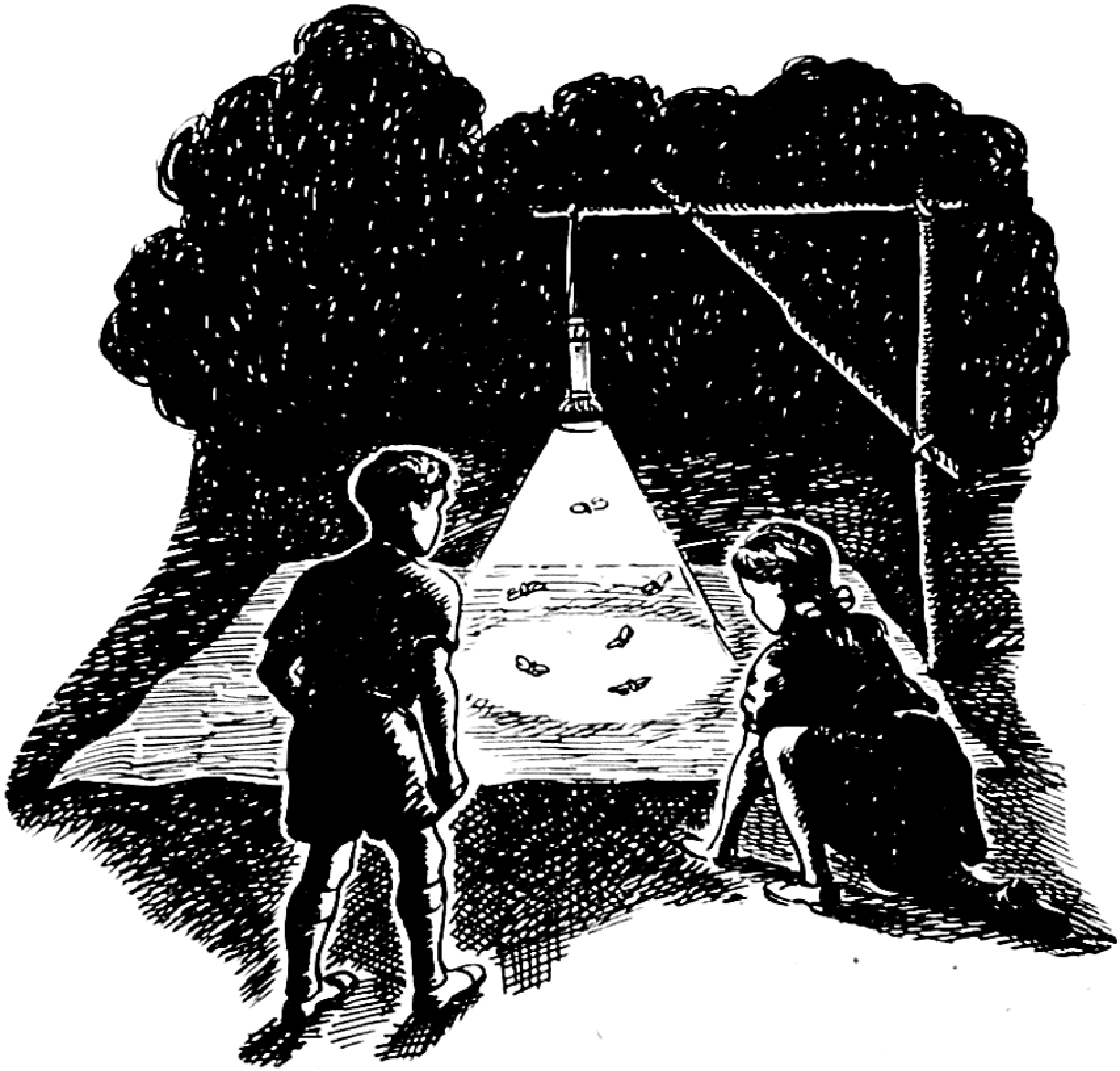


Some moths can be seen by day, but most of them are creatures of the dark.

There is adventure in your enterprise, and sport too—though not the sort of sport that will bring the moths to an untimely end. You are the hunter, but there is no need to kill your quarry. Your purpose is to see and enjoy these beautiful creatures in all the fullness of life, not to destroy them. But it *is* a sport nevertheless, because like the fisherman, you never know whether you will get a good 'catch' or not. Some nights will bring ample and exciting reward; on other occasions you will return home without having seen anything at all exciting. So do not give in if you are at first unsuccessful. He is a poor angler that gives up after a bad day.

Warm, still nights in June, July, and September are perhaps the best times to choose, though for some special kinds you will need to make your searches earlier in the year, in March or April. One day when the weather is quite still you may prepare your 'bait.' Try to avoid windy or moonlight nights—you will be more successful on dark nights after rain, or even when there is a slight drizzle falling. In order to make your bait you will need some brown sugar, some black treacle, and a teaspoonful of rum. (If you cannot get the rum, use a drop or two of rum essence, which can be bought at the chemist's. This will do, but it is not *quite* so good as the real thing.) Put a tablespoonful of the brown sugar into a cup and add a dessertspoonful of boiling water. Stir it up and leave it in the oven until it becomes a syrup. Now stir in the rum or rum essence, and fill the cup up with black treacle. When it is all stirred together you have your bait ready. The important thing to remember is that it should have a good strong smell, because it is the odour that will attract the moths from far and wide. If you want to make it stronger-smelling, you should use a spoonful of beer instead of water to dissolve the sugar.

This thick syrup is to be dabbed in patches about as big as a dinner plate on tree-trunks, or walls, or rocks. Go out about sunset and dab the bait on quite



On a suitable night many moths will be attracted by your 'snare.'

thickly with a piece of cloth. This may be done in the garden, of course, on the first occasion; but once you begin to see some of the more beautiful moths you will wish to go further afield in search of others. (You need not use very much of your syrup on each occasion—and the cupful should last you for several expeditions.) When it is quite dark return to the sugar patches with a torch. On a good night the sight will excite you—for there, sipping the heavy syrup, you will see these trembling creatures of the night in numerous variety. In the light of your torch you will be able to see them all quite clearly, and you should examine several of them carefully so that you can find out their names from a book when you get back. Perhaps there is an insect book in the school library.[1] There are about sixty different butterflies in England, but there are well over a thousand different kinds of moth, so look out for a good selection.

The second method you can use for attracting and observing moths can best be carried out in the garden at home. On a suitable night spread out a large sheet of white paper on the ground, and suspend a good strong torch above it so that the light shines on the paper. If you can arrange an electric lamp on a bed sheet spread out on the lawn, so much the better. On a good night dozens of moths of different kinds will be attracted by the bright light. It is almost as if they were hypnotized by it, and many of them land freely on the sheet, so that you can inspect them at close quarters quite easily. Really good nights do not often come along, but if you persevere you will most certainly be rewarded with a wonderful and unforgettable sight.

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[1] *An Insect Book for the Pocket*, by Edmund Sandars (Oxford, 1946), is perhaps the best small book.

THINGS TO DO

(1) Describe carefully any bird you know well. Give an idea of its size, colouring, and *character*. You will need to say something about its ways, its song, the times when you hear it sing, the sort of foods you have seen it eating, and so on. Entitle your composition 'A Bird I Know Well.'

(2) After your first adventure in a bird hide, write a composition entitled 'What I Saw from the Hide.'

(3) In your Country Book make drawings *of your own* showing three different kinds of birds. Label the drawings, and then write down three words (adjectives) that describe the characters of the three birds you have chosen.

(4) Find a poem about any bird that you know, and copy it neatly into your Country Book.

(5) Make drawings of any three night-flying moths that you have seen.

10

Some Flower 'Families' and Crop Plants

There sat I down among the faire flow'rs
And saw the birdës trip out of their bow'rs.
CHAUCER.

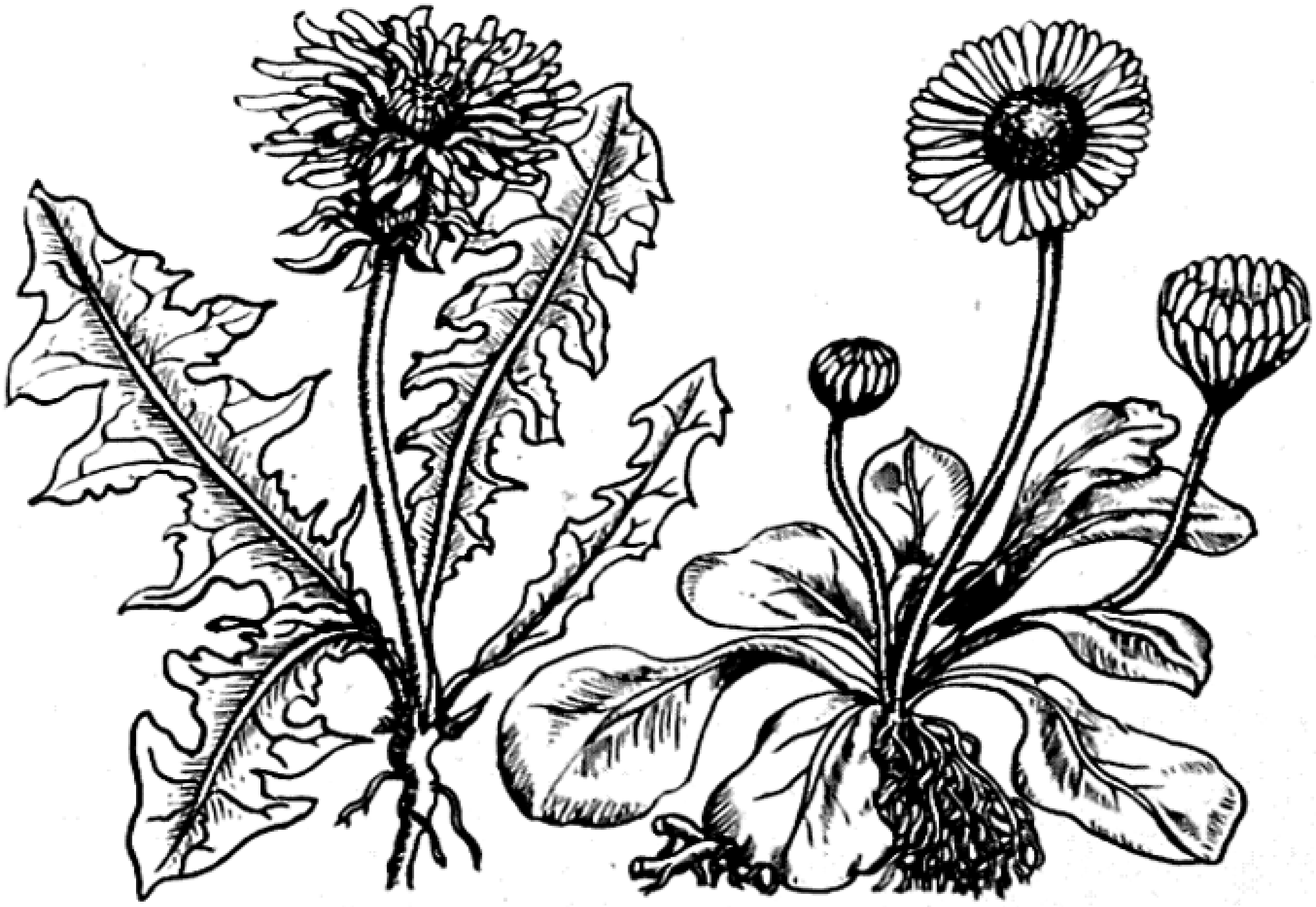
I know a bank whereon the wild thyme blows,
Where oxlips and the nodding violet grows
Quite over-canopied with luscious woodbine,
With sweet musk-roses and with eglantine.
A Midsummer Night's Dream (SHAKESPEARE).

IT is quite easy to think of close relationships between either tame or wild animals; and if you were trying to group animals together in 'families,' you would certainly put horses, donkeys, and even zebras in a group of their own because they look so much alike and they eat similar sorts of food. Nor would you have any difficulty in naming many members of the cat tribe; you would not hesitate to include the lion, leopard, tiger, panther, and many others—not forgetting your own fireside cat. Rats and mice are clearly related, and so are sheep and goats, moths and butterflies, bees and wasps. Indeed, every animal belongs to a family group of some kind, but plant relationships are often more difficult to observe.

General appearance is a very useful guide in the case of animals, but in the plant world, general appearances can be very deceptive, and we concentrate our attention on the *structure* of the flowers and fruits. If the flowers and fruits of several different plants are similar in certain ways, we may be sure that they are all members of the same family. This does not mean that all the plants in one group have flowers of the same colour or even of the same size. We attach more importance to such things as the shape of the flower, and the numbers of petals and stamens, and so on.

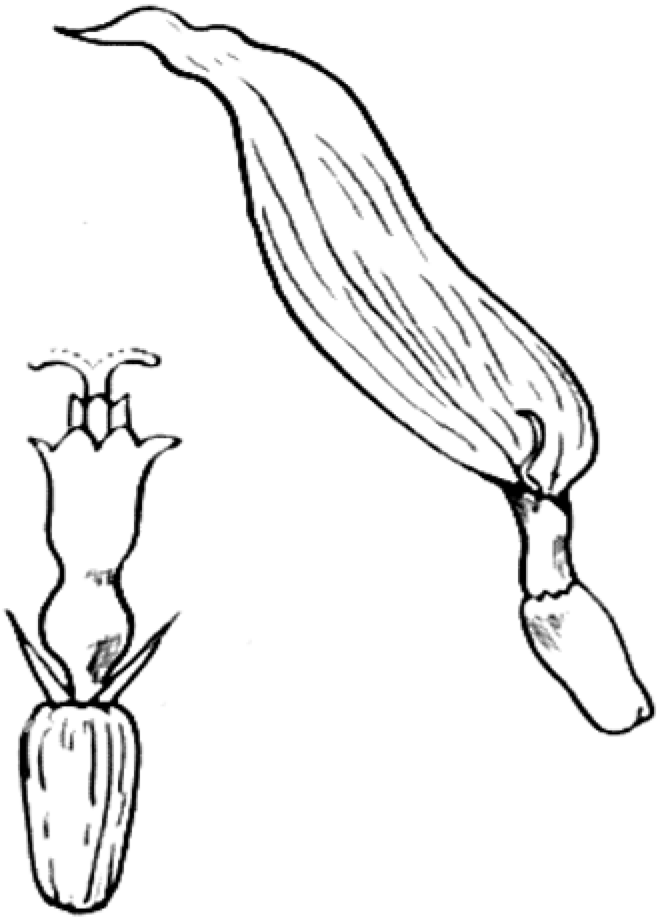
THE SUNFLOWER FAMILY

Sometimes, for example, a plant has a large number of tiny flowers all bunched together to look like one big flower. The dandelion really has a 'flower head' of this kind. So does the common daisy. If you look at either of these carefully you will be able to see masses of small flowers tightly packed together on one stem. Each 'petal' round the edge is really a separate



Two members of the COMPOSITE family—the dandelion and the common daisy.

flower (or floret), and if you look at the numerous tiny florets in the middle you will see that each one has its own stamens and pistil. If you are able to examine a large garden sunflower you will be able to see all these things much more clearly. Plants that have flowers of this kind belong to the COMPOSITE family. The word ‘composite’ is a very good name for these plants; it means ‘placed together’—so, you see, it really does describe the way in which the many florets grow together on one ‘flower head.’



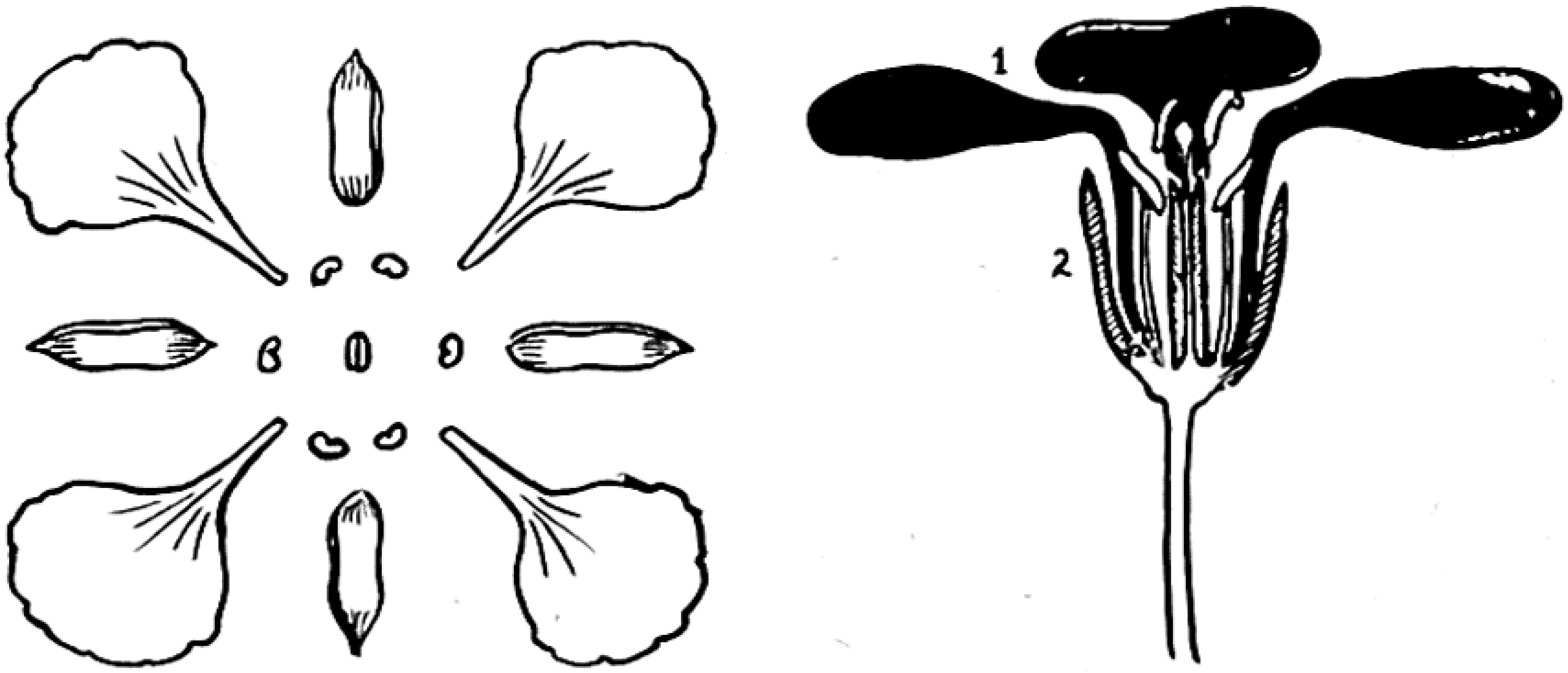
Some of the florets of the sunflower have a large petal; the others do not.

Can you think of any other members of this group? There are many of them, both in the flower garden and among wild plants. Thistles and Michaelmas daisies are composites, and you will readily think of many more. What about crop plants? None of our familiar farm crops are composites, and there is only one common garden crop that can claim membership of this group. That is the lettuce!

Perhaps you thought that the garden lettuce never bore flowers! It does, of course, otherwise we should never get any seed for sowing; and if you leave a lettuce plant in the ground long enough it will send up a long stem on which the yellow composite flowers appear in due course. Can you think of any weeds that have composite flowers? The groundsel and coltsfoot are the two commonest, but there are many others.

THE CROSS-SHAPED FLOWERS

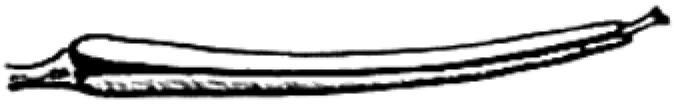
Another very large family of plants has flowers whose four petals are arranged in the form of a cross. Do you know another name for a cross? The Christian cross is very often called a *crucifix*, and we use a very similar word to name this family of plants. We call them CRUCIFERS, which means 'the cross-shaped ones.' This is a very important family indeed on the farm and garden, because all the different kinds of turnip and cabbage belong to it—turnips, swedes, kale, cauliflower, Brussels sprouts, and so on; all of them have the same kind of flower and all are crucifers.



Here you see the structure of a wallflower bloom. There are four sepals, four petals, six stamens, and one pistil. The flowers of all CRUCIFERS are similar to this.

The easiest specimen to examine is the garden wallflower, because it has the biggest flower. But the flowers of all the other members of this family are arranged on the same plan, no matter how small they are. Let us examine the wallflower bloom carefully. You will easily be able to notice the cross-shape made by the four petals, and if you count the green sepals you will see that there are four of them also. Two of these have a small 'bulge' at the bottom. Pull these two from the flower stem and examine carefully the part of the stem to which they were attached. You will find two tiny drops of sugary liquid. This is the nectar that the flower produces in order to attract insects. Bees make their honey out of nectar, as you know, and it is in order to collect these tiny drops of sweet syrup that the honey-making workers visit the plant.

If you take off all four sepals and all four petals you are left with the two remaining parts of the flower—the two most important parts—the stamens and the pistil. There are six stamens arranged round the single pistil in the middle. The stamens are the male part of the flower and their anthers manufacture the pollen which the female part—the pistil—must receive in order to produce fruit and seed. Perhaps some of the blooms on your wallflower stem have already been pollinated. If this is so you will be able to examine the partly grown pod-like fruit, and inside it you will be able to find the partially formed seeds. Later on, when the fruit is ripe, these seeds will be quite hard and covered with a dark-coloured testa; at present, however, they are soft and green, because nature has not yet finished making the baby plants.



This pod-like fruit of the wallflower contains the seeds.

The wallflower bloom is *typical* of all the crucifer flowers. The white flowers of the turnip and the yellow flowers of the cabbage are rather smaller, but they have exactly the same *structure.* Nobody would ever think of putting together in one family two plants so different in appearance as the wallflower and the cabbage unless they examined their flowers first. The appearance of the leaves alone would lead you to think that the cabbage was more nearly related to the lettuce, but, as you have seen, the lettuce belongs to a different family altogether.

Many of the plants in the crucifer family have a 'sharp' flavour when they are eaten; indeed both table mustard and horse-radish sauce—the two 'hot' condiments that we eat with roast beef—are made from plants in this family. Yellow mustard powder is made by grinding up the seeds of the mustard plant after the testa has been taken off; and horse-radish sauce is made from the swollen underground stems of the horse-radish plant. The garden radish, too, is a crucifer, and it has a similar sharp flavour when it is eaten; so does watercress; and the tiny white cross-shaped flowers of the watercress plant show quite clearly that this is yet another member of the same plant group. Why does nature give this hot taste to these plants? Perhaps it is her way of protecting them from insects that might otherwise eat them? If so, it seems strange that we should eat them ourselves just because they have this appetizing flavour!

When you were learning about the farmer's crop rotation in Book I, you discovered that one of the important reasons for changing the crops about was the need to avoid infesting the soil with any particular crop pest or disease. The potato eelworm, for instance, is kept in check by growing potatoes on different fields each year, so that any eelworms left in the soil where potatoes have been grown will die for want of food. You will now be able to understand another of the farmer's troubles. There is a disease called club root, or finger and toe disease, which attacks any farm or garden crops that belong to the crucifer family — turnips, cabbage, kale, all are subject to an attack. This is one reason why the farmer includes all these things together under the name 'root crops'—they all move from field to field together, and because of their close relationship they can, so far as disease is concerned, be looked upon as one kind of crop.

Charlock is one of the crucifers and it is a troublesome annual weed. Do you know the colour of its flowers?

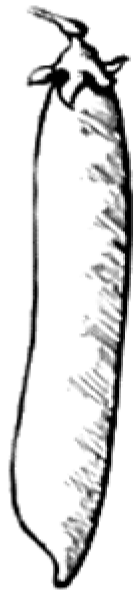
If these crops are grown on a fresh field each year, there is little risk of the soil becoming infested with the club root disease which dies out after two or three years if there is no crucifer plant for it to live on. *Unfortunately*, however, two very common weeds are members of this family—the charlock and the shepherd's purse—and if these are allowed to grow unchecked, finger and toe disease is kept alive in the soil by their presence. They are said to be 'host' plants for the disease. Here, then, is another very important reason for keeping weeds in check; not only do they rob the crops, they may also spread disease. However, even if the club root does become troublesome, the farmer can control it to some extent by giving his fields a good dressing of lime. The disease does best in acid land and, as you know, the lime destroys any sourness in the soil, and so tends to kill the disease at the same time.

THE 'BUTTERFLY'-SHAPED FLOWERS

One of the prettiest flowers for decorating the house is the sweet pea. It is a very delicate bloom indeed—for it has frail, beautifully shaped petals, as well as being attractively coloured, and sweetly scented. This annual flower first came to us from Italy just over two hundred years ago; so that it was a flower quite unknown to the British people before that time. If you had lived in the days of Shakespeare or, later, in the days of Oliver Cromwell, it would have been quite impossible for you to go into the garden for a bunch of annual sweet peas! This is one of the flowers in the LEGUME family, and as it is quite large and easy to examine it will serve us as a specimen.

You will see that it differs very much from both the composite and the crucifer flowers. It is of an irregular shape. There are five petals, but some of these are much bigger than the others. The largest, called the *standard* petal, is at the back; then come two similar petals, one on each side, called the *wings*; and in the centre of the flower there are two more that fit closely together, forming what is called the *keel*, because it looks rather like the keel of a boat. If you examine the green sepals you will see that they are not separate from one another: there are five of them, but they are joined together in the form of a short tube that has five teeth.

The seed-making parts of the flower—the stamens and the pistil—are to be found inside the keel. You will need to look at these parts carefully, for nine of the ten stamens are joined together to form a tube round the pistil, and the tenth stamen is quite separate. If you take all the stamens away you are left with the pistil, which is shaped like a small pod and contains the beginning of the seeds. This is the part of the flower that will grow into the fruit, which is a pod—rather like an ordinary pea pod. All the plants in the LEGUME family have flowers that are very similar to the sweet pea, and all of them bear their seeds in pods. Indeed, it is because of their pods that members of the group are called legumes—'legume' being the French word for a pod.


A pod of the garden pea. The fruits of all legumes are pods.

There are very many members of the legume family among both farm and garden plants; and many of our wild flowers are legumes also. On the farm we have the different clovers, the peas, and the beans. If you look at the flowers of these crops you will see that they are very similar indeed to the sweet pea flower. In our gardens we cultivate runner beans and French beans, as well as the garden pea and broad bean, and the appearance of their flowers will tell you that the too belong to this family. The lovely spring-flowering laburnum, the many different kinds of broom, and the sweet pea are the three *leguminous* plants most often cultivated in our gardens for their attractive blooms.

Many of these plants came to us in the first place from other countries—runner beans from South America, peas and broad beans from Italy, laburnums from central Europe, and the garden broom from Spain. Butcher's broom—sprays of which can often be seen in the florist's shop—is not a member of the legume family. It has a different kind of flower altogether. If we wish to find examples of important *native* crop plants of the legume family we must leave the garden and explore the farm fields.

Two important members of the legume family—wild white clover and vetch.

In some parts of the country we shall find the farmer growing tares. This is an annual legume—known also as common vetch because it is often found as a wild flower in the hedgerows—and it is frequently grown on farm fields as a fodder for cattle. Then there are the various native clovers and trefoils that we shall find growing in pastureland or in hayfields. These, too, are legumes—and what attractive names some of them have: bird's-foot trefoil, yellow suckling clover, black medick, broad red clover . . . there are many of them, and we must make special mention of the humble but valuable wild white clover, which is a *very* valuable plant indeed. We should have less milk in Britain if there was no wild white clover in our pastures for the cows to eat. Even so, the farmer grows many *strains* of clovers that are not native; they have come to us from countries as far apart as Holland and New Zealand!

Red clover is grown chiefly for hay. A pod of this plant contains only one seed.

Not only do the leguminous plants of farm and garden produce valuable crops—they also enrich the soil on which they grow with a substance that is used by all plants in small quantities. You were told in Book I (Chapter 5) that plants took in large quantities of water from the soil through their roots, and that very small quantities of other *indispensable* substances went in with the water. One of these substances is called NITRATE. and this is the substance with which leguminous plants enrich the soil. If you take up any

The beautiful laburnum belongs to the same family as the garden pea! Beware of its pods and seeds, however. They are extremely poisonous.

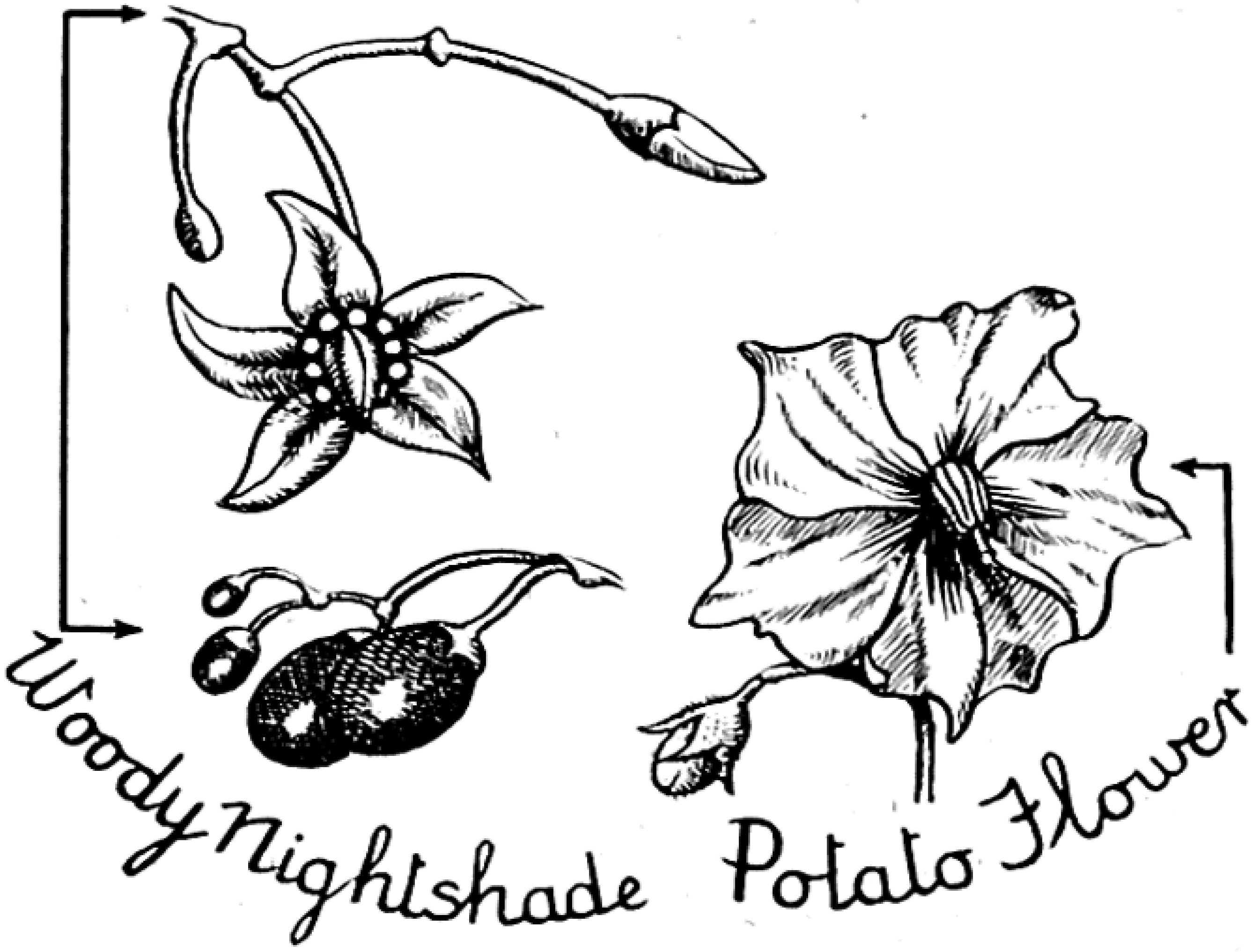
leguminous plant and examine it, you will find hard lumps all over its roots. These *nodules* contain some nitrate materials, and if the farmer or gardener leaves the roots of his leguminous crops in the soil when the crop goes off, the land will be the richer for them, and the next year's plants will get the benefit. If you grow your peas and beans in a different part of the garden each year, the whole garden will be enriched by their roots as time goes on; but you must be careful not to pull up the roots when you remove the dead stems and leaves. Farmers are quite well aware of the way in which leguminous plants restore the condition of their soil; and it is because of this that they often include a 'seeds' crop in their rotations. This 'seeds' crop consists of grass and clover, and as well as providing hay and grazing, the clover in the crop also acts as a tonic to the soil.

You will be interested to know that there are no serious weeds in this family! Indeed there is only one weed in the family at all—and that is a grassland weed called rest-harrow. It is regarded as a weed because it is very tough and cows cannot eat it. Although it may be found in many parts of England it is not very common as a weed in farmland. Most of the wild legumes, such as the various uncultivated vetches, are to be found only along the hedgerows where they do no harm. Their fruits are tiny pods, but you should not eat the 'peas' inside them as they are mostly poisonous.

THE POTATO FAMILY

Along the hedgerows in the late summer you will often come across tassels of shiny oval berries that are of a brilliant red colour. These are the poisonous fruits of the woody nightshade, and very often you will find some of the yellow and purple flowers growing alongside the berries. Not many flowers have two distinct colours, but this one has. There are five purple petals arranged like a star, and there is a small cone of yellow stamens sticking up in the middle.

The woody nightshade—or bittersweet, as it is also called—is the only *common* British wild flower that belongs to the same family as the potato. There are two or three others that are much less common, and one of them—the deadly nightshade—is rather rare. This is very fortunate, as it is extremely poisonous—one or two berries being enough to kill you. You will be glad to know that the potato family goes even 'one better' than the legume family—it contains no weed plants at all!



These two plants—one native and one foreign—belong to the same family.

This, then, is a very small family in Britain, and the potato is the member that you are likely to know best of all—unless your father grows the tomato, which is another member of the same group. If you compare the flowers of the tomato and the potato you will find that they are very similar, and that they bear a strong

The tomato is a close relation of the potato.

resemblance to the flower of the woody nightshade. In each case there are five sepals, five petals, and five stamens — and the stamens are attached to the petals! Indeed, there are not many separate parts in these flowers at all, for the five sepals are all joined together, and so are the five petals. In each case, also, the pistil eventually develops into a juicy berry. It is not likely that you have seen the berries of the potato in which the true potato seeds are to be found, because they do not often develop on potatoes that are grown in farm fields; but you have eaten the tomato berries quite often, no doubt! Both these plants were brought into this country from the warm parts of South America. That is why neither of them will resist the frost. There never is any frost in their natural homes. Although they were brought to England in the adventurous days of Queen Elizabeth, when Drake and Raleigh and Grenville were sailing proudly over the Seven Seas, neither the potato nor the tomato was cultivated on a big scale for more than two centuries! Think of that! Tomatoes and potatoes in this country for two hundred years and not much use being made of them! We should find it hard to do without them to-day. It is often said that Sir Walter Raleigh first brought the potato to England; but there is some doubt about this. It seems that a man named Hariot should get the credit; he was an important scientist, and was leader of the colony of Virginia that Raleigh founded in America.

You have been learning about four of the most important plant families in Britain; and these four families were chosen because many of our farm crops and garden plants belong to them. There are, however, very many other families in Britain alone—almost a hundred. Perhaps you will be able to arrange other plants in families for yourself. Remember always to examine the flowers carefully when doing this kind of work—count the petals and stamens and compare the fruits. You might make a good start with the rose family. The dog-rose and the cherry are two members; see if you can find others.

THINGS TO DO

(1) Suppose yourself to be looking at two pictures in an art gallery—one of Alfred the Great, the other of Sir Walter Raleigh. Slowly they come to life and talk to one another about the large picture of a modern garden on the opposite wall. Write a composition describing this event. Remember that there were no gardens in Alfred's day at all and that some of the plants, though not all, would be strange to Raleigh. King Alfred would probably have a word or two to say about Raleigh's 'strange' clothing.

(2) Write single sentences in answer to the following questions:

- (*a*) Why are the flowers of many plants brightly coloured?
- (*b*) What substance—useless to themselves—do some flowers produce?
- (*c*) Do you think hazel catkins produce this substance? (Give a reason for your answer.)
- (*d*) To what family does the garden marigold belong?
- (*e*) What name do we give to the family of cross-shaped flowers like the wallflower?
- (*f*) Why can we say that two plants of very different appearance—such as the cabbage and the water-cress—belong to the same family?
- (*g*) In what way can the weeds, charlock and shepherd's purse, be dangerous to good farming?
- (*h*) To what family of plants do the pea and the bean belong?
- (*i*) In what way do leguminous crops improve soil?
- (*j*) Write a short paragraph entitled, 'The Services that Bees and some Flowers perform for one another.'

(3) Try to find at least three different wild flowers of each of the COMPOSITE, CRUCIFER, and LEGUME families. Bring these to school for the nature table. They should be neatly labelled with both the name of the flower and the family. Altogether, the whole class should get at least twelve members of each family.

(4) In your Country Book make simple neat drawings of a crucifer flower, a composite flower, and a legume flower. These should be 'top' views. Name each one.

(5) Bring to school three wild flowers that you think belong to the same family but which are not composites, crucifers, or legumes. Label them with their names and put them on the nature table for the rest of the class to see.

11

‘Into the Scented Woods We’ll Go’

> A tree whose hungry mouth is press’d
> Against the earth’s sweet-flowing breast.
>
> JOYCE KILMER.

IF you have been holding a bunch of wild flowers in your hand for a long time they very often begin to droop or ‘wilt’; and if you put them into water they will ‘pick up’ again, as we say. Why is this? A good big bunch of flowers will soon drink up a whole glassful of water, so that you need to give them more each day. It seems that when the water gets inside the soft parts of the plant it keeps them firm and stops them wilting. But why is it necessary to go on giving them more water? Do they use it up in some way?

You have learnt that plants do use a great deal of water for making sugar, but a single bunch of flowers could not use a whole glassful of water for sugar making only. If they did they would grow much bigger than they do after you put them in water. Here, then, is a mystery that needs solving—into the plant goes a lot of water that is not used for sugar making. What becomes of it? Let us carry out an experiment.

PLANTS PUMP WATER INTO THE AIR

Experiment 1. You will need two small bottles—small medicine bottles will do very well indeed. Fill them with water. Now take two large newly grown leaves that are about the same size. Potato leaves are quite a good sort to use. Put one leaf into each of the two bottles, so that the bottoms of the stems reach well down into the water, and plug the bottle-necks with

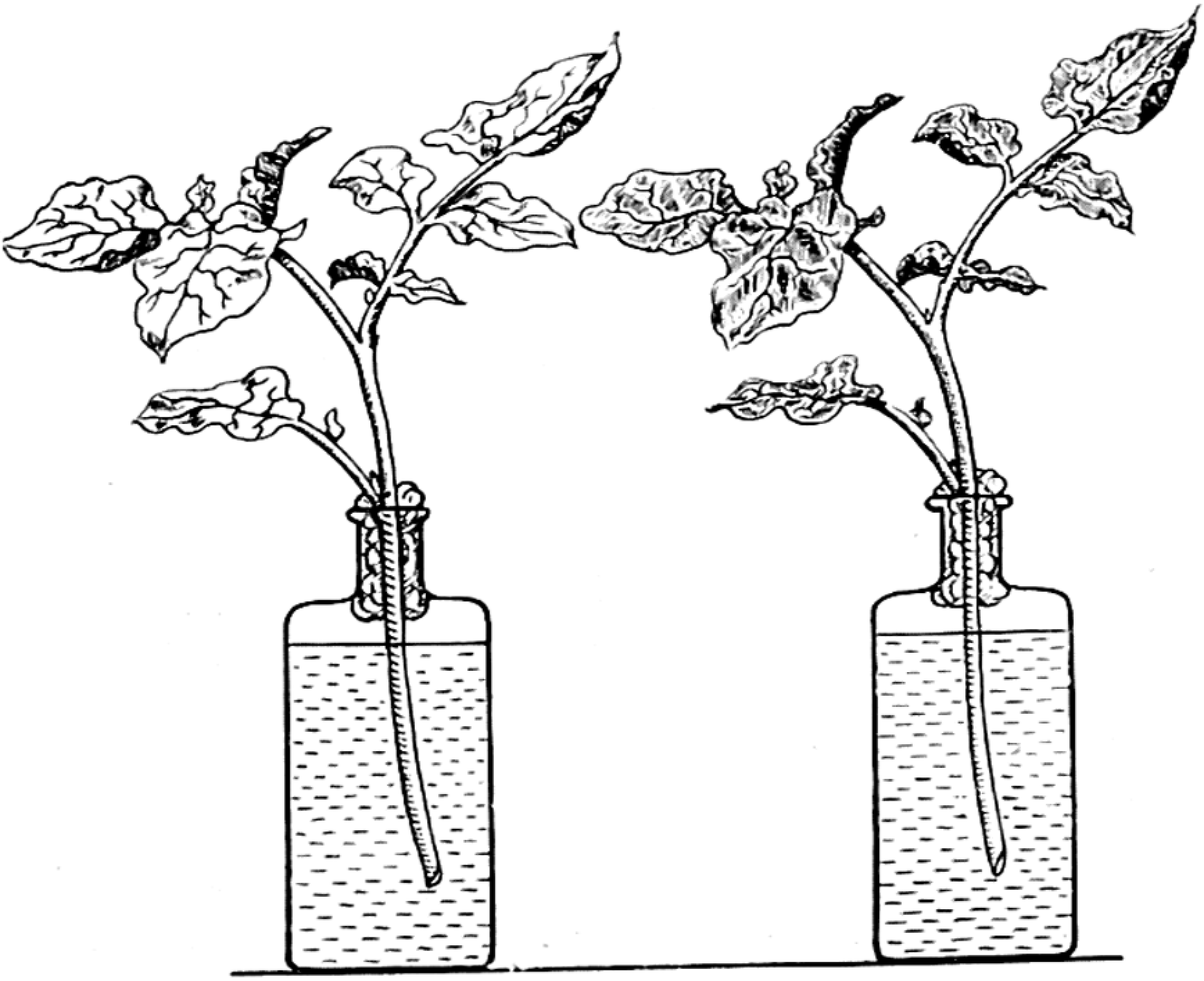


Illustration of Experiment 1. The leaves on the right are smeared with vaseline.

cotton wool. Smear vaseline (or some similar grease) over *both sides* of one of the leaves, and then place your bottles on the window ledge for a few hours. You will very soon see that the water in the bottle that contains the untreated leaf begins to be used up, whereas the other bottle remains full.

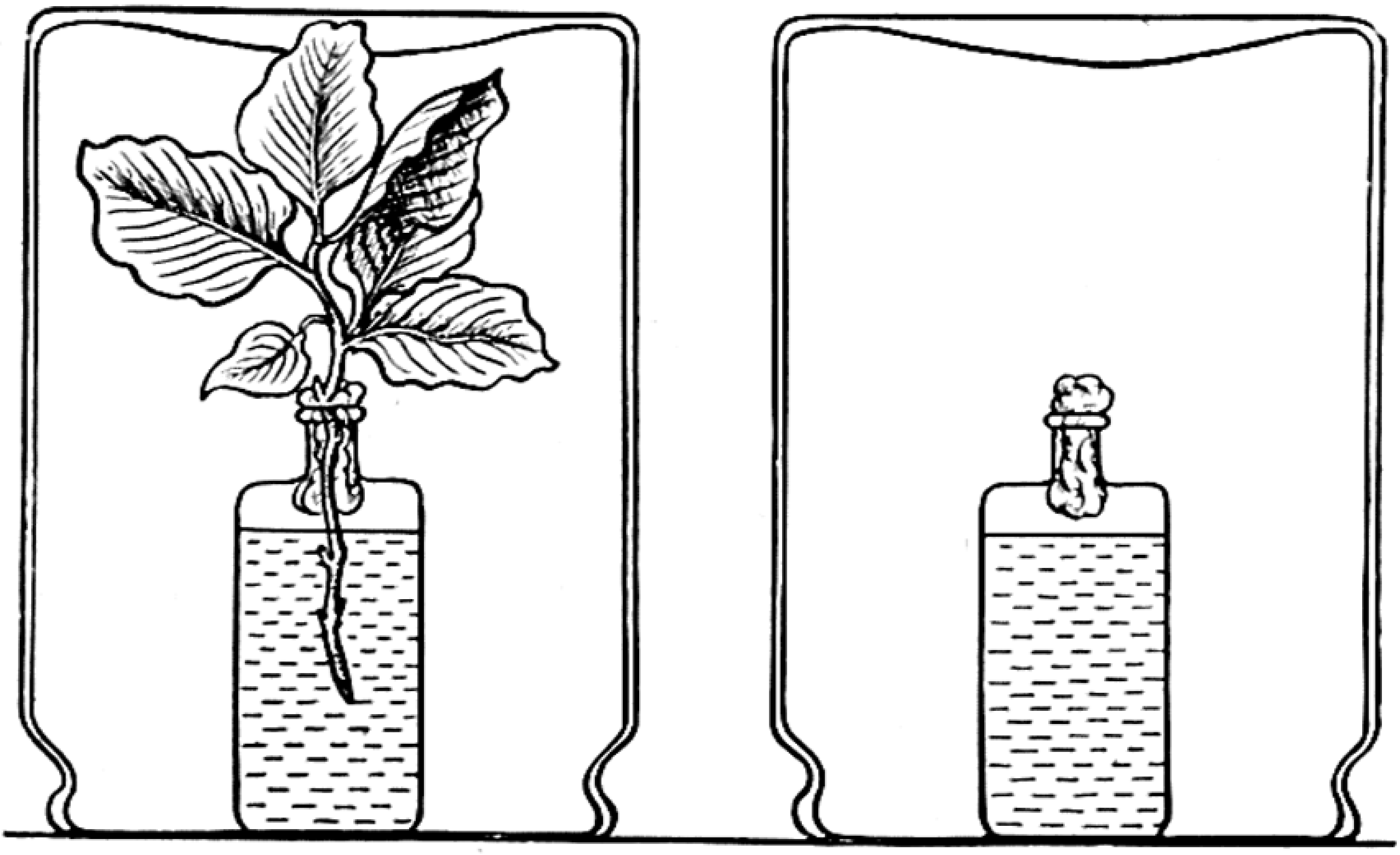
This experiment shows us that the water used up by the untouched leaf must be coming out into the air in some way.

You learnt in Chapter 6 that there are millions of tiny pores or *stomata* in the skin of the leaf through which the plant takes in oxygen for breathing and carbon dioxide for making sugar. It is through these same pores that the plant sends out water into the air—so you see, the stomata on the leaf have *three* uses altogether. When you smeared one of the leaves with vaseline you blocked up all these pores, so that no water could get out into the atmosphere—and the bottle remained full. The other leaf, however, was able to let the water through its pores, so that the water in that bottle soon began to disappear. *The leaf was pumping the water into the air!*

We can prove that this really does happen by doing another simple experiment.

Experiment 2. How to collect the Water that a Leaf pumps out. Fix another leaf into a small bottle, as you did in Experiment 1. This time the leaf and the bottle should both be smaller, so that you can place a dry 2-lb. jam jar over the top of them. Place the bottle on the window ledge and cover it with the jam jar as shown in the illustration opposite. Make sure that the jar is quite dry inside to begin with. After about a day, examine the jar carefully. You will see that a good deal of water has settled on the inside, but that there is none at all on the outside.

Water has been pumped out of the bottle by the leaf and has collected on the inside of the jar. But how did it get through the air on to the jar? In order to answer this question, let us first ask ourselves another one. If you leave a saucerful of water in the open air on a dry day in summer the water disappears. If you have never noticed that this happens, try the experiment for yourself. In the same way, when your mother hangs wet clothes on the clothes-line on a nice windy day, they are soon dry. What happens to all the water? Has it been *destroyed*? The answer is that water can change into an invisible gas and go into the air in this form. We call this gas *water vapour*, and we say that the liquid water has *evaporated*. It is possible for this water vapour to turn back again into liquid water; and that is what happened on the inside of the jar you used in Experiment 2. The leaf sucked the water out of the bottle and then pumped it into the air in the form of


You will get good results from Experiment 2 if you use fleshy leaves such as those of the petato.

invisible water vapour. When this vapour got to the glass jar it turned back into the liquid water that you could see.

A crop of wheat pumps hundreds of tons of water into the air!

NATURAL WATER PUMPS

When plants are growing, they are continually taking water from the soil and passing it into the air in this way. You will be surprised to learn just how much water is removed from soil by this process of TRANSPIRATION, as it is called. It has been calculated that one acre of wheat pumps *five hundred tons* of water into the air during one summer season!—so that a small ten-acre field has to supply the wheat with five thousand tons of water in one season! You may wonder where all this comes from in time of drought! Remember, however, that clay and humus are able to act like a sponge and soak up tremendous quantities of water; and a good fertile soil always has plenty of clay and humus in it. You know very well that crops on sandy soils soon 'burn up' in a dry summer for want of moisture. That is because a 'light' soil does not contain much clay in which to store up the winter rains. You will realize from what you have just learnt about transpiration that a farmer could not possibly 'water' his fields in a dry time because he could not possibly handle so much liquid. Instead, he puts farmyard manure into the land, so that the soil can store up nature's rainfall for itself.

THE IMPORTANT WORK DONE BY FORESTS

If small plants like wheat *transpire* so much water, what about trees? These are the earth's great water pumps. Even a small woodland removes hundreds of tons of water from the soil *every day*. Now this is a very important fact, and if it had been understood by the American people a hundred years ago, there would not have been so many disastrous floods in the valley of the River Mississippi as there have been. Perhaps you have not heard about these great floods? For more than fifty years now, this tremendous American river has from time to time flooded the cities along its course—many people have been drowned, and much poverty and misery have been caused. These great floods still occur in wet seasons, and you may sometimes see pictures of them at the cinema.

What has all this to do with trees, however? The story is a sad one, because it is a story of ignorance and of greed—a story of men trying to make themselves rich by thoughtless behaviour; and greedy behaviour always brings disaster in its train sooner or later. Unfortunately, it is not always the people that are the cause of trouble that have to suffer so terribly when it comes. Until about the middle of the nineteenth century the great Mississippi River had behaved itself perfectly well—there had been no flooding at all. Then large numbers of Americans found the tremendous forests that surrounded the *headwaters* of the Mississippi basin. They went up all the *tributaries* of the river—up to the hills and mountains of Oklahoma and Iowa, Wisconsin and Ohio, and into the Alleghanies. In these hills and mountains lie the sources of the great river; and it is the rain that falls on these distant slopes that feeds the Mississippi with water. What did these adventurous pioneers do? Thoughtlessly they set to work to cut down all the trees they found, and in the space of twenty or thirty years they had made themselves rich by selling the timber, and they built many cities along the banks of the Mississippi. They were very prosperous indeed, and their plentiful timber sold all over the world. It was a time of gaiety and a time of plenty. Nobody need go short of anything. . . . But what was happening away in the distant hills? The forests were gone; there was no longer any check to the teeming rains when they came. Instead of large quantities of the rainfall being pumped back into the atmosphere by the great trees, all the rain that fell got into the rivers; and these swollen tributaries flowed down to join the Mississippi. Then came disaster. In the wet seasons the water of the rising river engulfed the prosperous cities lying along its banks; cities whose buildings were made of the very timber that would have pumped these swirling torrents of water back into the air—if the trees had been left standing in the distant hills.

Man has, however, learnt a lesson from his folly. Nowadays, for example, when a *reservoir* is being made to supply the water for a town, trees are planted in great numbers on the surrounding hills. These are put there to pump some of the water back into the air in time of heavy rainfall, so that the streams that feed the reservoir shall not become too swollen. If they did they would carry down great quantities of muddy water into the reservoir and *silt* it up. If you get a chance of seeing a *water-catchment* area like this, notice the trees that have been planted, and remember why they are there.

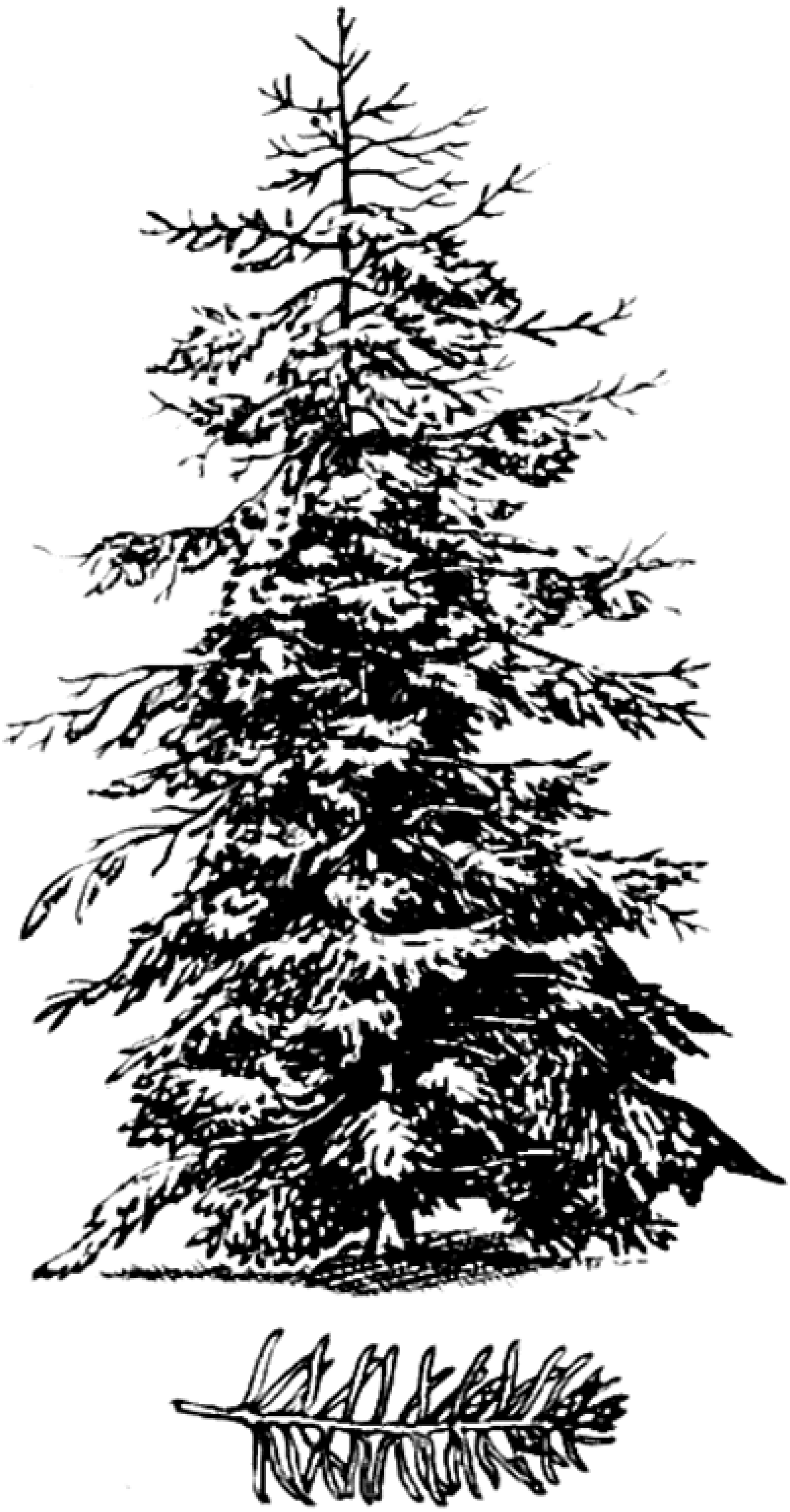
NEW TREES IN BRITAIN'S WOODLAND

Just as most of our farm and garden crops have been brought into this country from abroad, so also have many of our important timber trees. Why is this? Did not our ancient British forests produce oak and ash and beech of the best quality? They did indeed; and we should be glad if our forests were full of our native trees to-day. Nevertheless, the trees we mostly plant in Britain nowadays are foreigners like spruce and larch and Douglas fir; and this is because these foreign timbers grow more rapidly than do our native oak and ash and beech. You see, timber is a crop; and we need as much of it as we can get, so we choose to plant our woods with trees that produce the greatest amount of timber in the shortest possible time. In addition to this, some of these foreign trees will grow well in places that are not very suitable for our own trees. Spruce, for example, grows well in poor soils and on high hillsides that would be quite unsuitable for trees like the oak; and the Douglas firs will thrive in the damp valleys of western Britain—in acid soils that would provide a poor home for the ash. Let us learn to recognize the three most common ones: Douglas fir, spruce, and larch. All these three trees bear their seeds in CONES, and for this reason we call them CONIFERS.

THE DOUGLAS FIR

The Douglas fir is a truly remarkable tree. When it is past the sapling stage it will grow two feet each year, and there is one in England that is already over two hundred feet high! This particular tree is not much more than a hundred years old, and it is still growing bigger. Douglas firs in western America, which is their native home, commonly reach a height of three hundred feet—as high as some of our factory chimneys! Not only does the Douglas fir grow rapidly in height, it also grows to a great *girth* or thickness, so that, when fully grown, a single tree contains much more timber than the biggest oak-tree. Foresters have found it to be such a good grower that it has now become the favourite tree for planting in some of our forests, and we shall see it more and more as we go about the countryside—especially in upland valleys where it is sheltered from strong winds.

The tree is very easy to recognize. It is an *evergreen*, and in the winter the new buds may be seen on the outer twigs of the tree. They are like the buds of the beech-tree and have the appearance of small brown cigars. When the new shoots have grown in the spring, you will find that they are quite long—some five or six inches—and that there is a row of needle-like leaves on each side of each young stem. When you pull one of these needles away it leaves a tiny round scar. If you will look for these three things on the outer twigs you will have no difficulty in naming the tree. Remember that the Douglas fir was first brought to this country from America by a man named Douglas just over a hundred years ago. It would be quite unknown to people in Britain before that time. Our own forests of Douglas fir have not yet given us much timber, as they are not fully grown. But in America it is the most commonly used wood



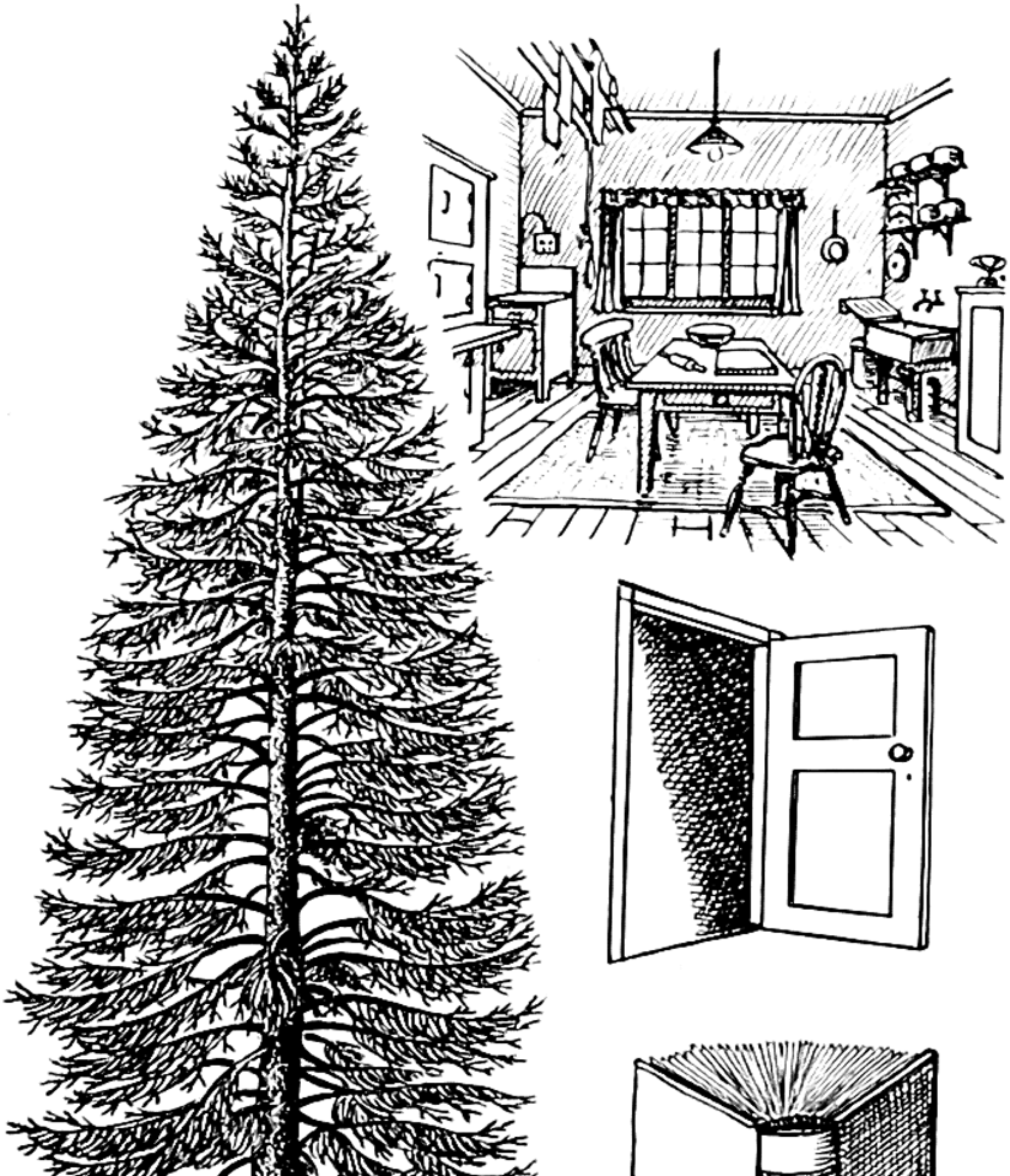
We have no fully grown Douglas firs in this country. Do you know why?

and is called 'Oregon pine.' It is used for all sorts of things: ships' masts, bridges, houses, paper-making, and so on. At present we have to buy our Oregon pine from America, but when our own woods of Douglas fir are more mature, we shall be able to fell our own trees and use home-grown Oregon pine as well.

THE SPRUCE-TREE

Another very common timber is white deal, and you very probably use it at times in your woodwork classes. This is the wood of the spruce-tree, which grows freely in the forests of western Norway and in Germany. It first came to us from Norway a few centuries ago and is now one of our most common forest trees. Young spruce-trees are cone-shaped, and they are used as Christmas trees both in Britain and on the Continent. It is not very long ago—less than a hundred years—since we first began to have decorated Christmas trees in our homes at Christmas time. British children who lived in the first half of the nineteenth century never saw a candle-lit tree in their homes at Christmas; but the custom is an ancient one in Germany—and it was from the Germans that we adopted the pleasant idea. The tree is very beautiful in itself, but when it is adorned with all its glittering jewels, its ornaments, and presents, it is resplendent and a great joy to behold.

You can easily recognize the tree from its long shoots with very short green needles. When the needles fall off, they leave behind a notchy stem which is very rough to the touch. No doubt you have



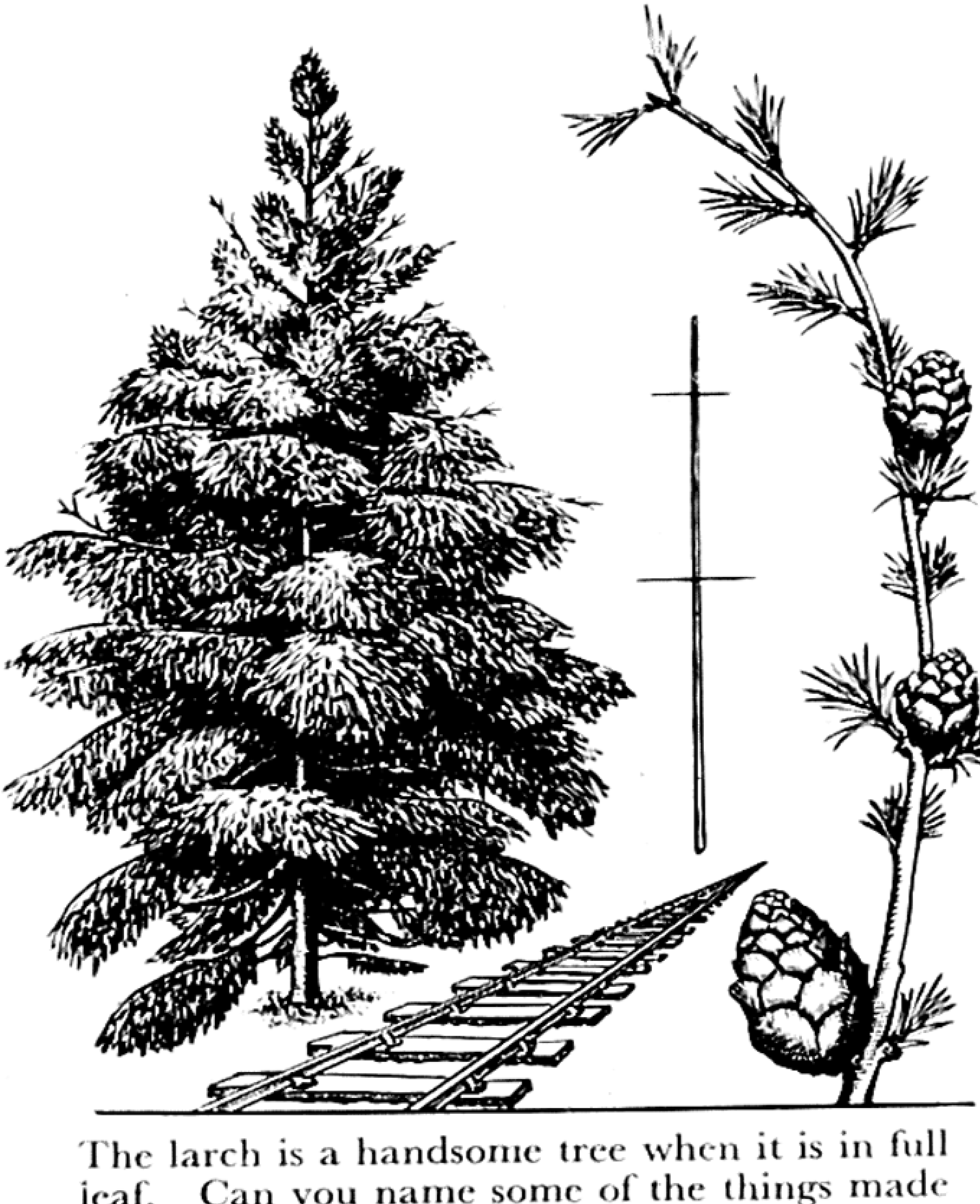
If you have ever seen a Christmas tree you have seen a young spruce! What name do we give to the timber of this tree? Notice that its spruce timber is used for indoor articles.

noticed this when you have been getting the Christmas tree fixed up in a tub or bucket of soil ready for the Great Day!

White deal is a soft timber that is used mostly for furnishings in the home, as it does not 'wear' very well out of doors. It is used for such things as doors, floor-boards, box-making, and for wood-pulp. Indeed, most of our newspapers are printed on paper that is made from the wood of the 'Christmas tree'! Hundreds of tons of timber are used every day for paper making, and the spruce is the most important source of this paper-making wood. If you are a musician you will be interested to know that violins are often made of spruce wood. For some reason it is very suitable for this purpose.

THE LARCH-TREE

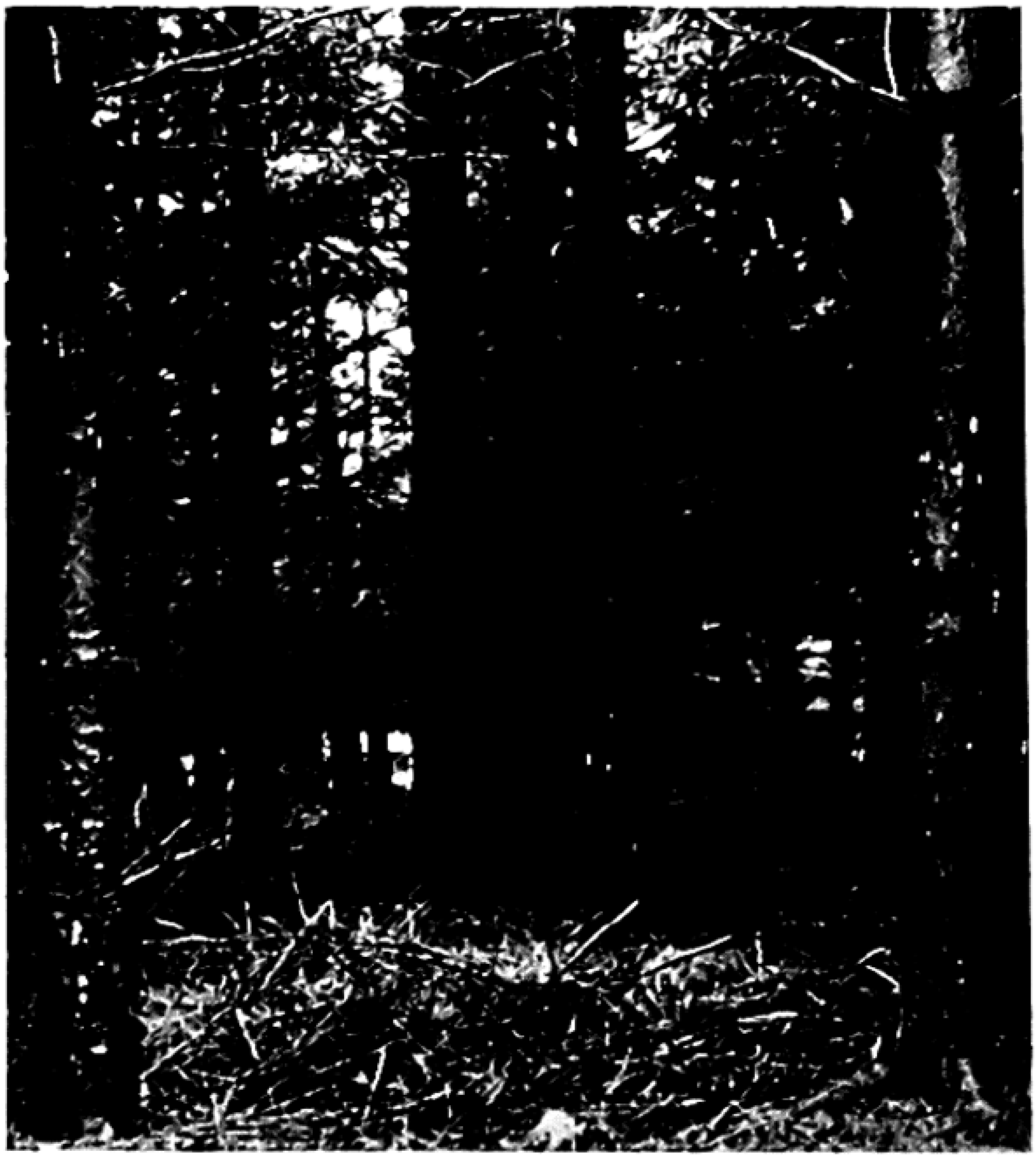
There is perhaps no more beautiful country sight than the graceful picture of the larch woods in early spring. The larch-tree is a conifer like the Douglas fir and the spruce, but unlike them it is not an evergreen tree. It sheds its tiny needles in the autumn and grows a completely new set in the spring. The buds begin to open in March or April, and their lovely fresh green colour spreads like a soft mist across the woodlands. If you come closer to the woodside you will see that the twigs are so slender that they hang in long tresses from the tree and the new leaves are borne in little tufts along them. A little later on the beautiful flowers called 'larch roses' begin to open. These pink round bobs are really collections of female flowers. That is to say, they contain pistils but no stamens. You will find some male flowers on the same spray, however, and these bear the yellow stamens. After the 'roses' have been fertilized by the pollen they develop into larch cones, which contain numerous winged seeds. In the late autumn and the winter you will often see groups of tits busily engaged among the larches. They are, of course, plundering



The larch is a handsome tree when it is in full leaf. Can you name some of the things made from larch timber?

the cones in which they search diligently for the seeds.

You may find that a walk through a wood of young firs or of young spruce-trees is rather a grim affair.



There are not many small green plants growing in the gloom of such coniferous plantations as this.

These woodlands are very dark, and a few plants can grow on the woodland floor. But a walk through the larch woods is a very great pleasure indeed. The trees allow plenty of light to come through their branches in spring, so that the ground beneath is often clothed with an abundance of wild plants.

Most of our telegraph poles are made from the tall straight trunks of the larch-tree, and the wood is very durable, so that, unlike the white deal that we get from the spruce, it can be used for all sorts of purposes

There is plenty of light in the larch woods in spring, because larches are deciduous trees.

out of doors. It is in great demand for the making of things like bridges, boats, buildings, railway sleepers, ships' masts, and so on. There is no need to remember all these things, but you should remember that larch timber can be used out of doors, whereas spruce timber cannot. And you should bear in mind, also, that good English oak would be better still for many of these purposes; it does not, however, grow quickly enough to provide the great quantities of timber that we need.

There is a special name given to the timbers that come from the cone-bearing trees. They are called *softwoods*. Broad-leaved trees like the oak and the ash produce *hardwoods*. We may regret that it is not possible for us to have more oak woods and beech woods instead of filling our forests with these foreign conifers. Apart from the larch, they are certainly not so picturesque as the broad-leaved trees. However, we cannot 'have it both ways'—if we want the extra timber we must be content to plant the less picturesque trees in our woodlands. But even though they do not appeal to the eye, they have a pleasant effect on the nose! Everybody loves the refreshing smell of the 'pinewoods.' It is to be hoped, however, that some hardwood trees will be planted in places suitable to them. It would be wrong to lose all our native trees. Those who come after us in the new centuries would be bereft of their birthright.

THINGS TO DO

(1) Write three short paragraphs entitled 'Natural Water Pumps and how they Work'; 'Floods on the Mississippi'; and 'Foreign Forest Trees and Why we Plant them.'

(2) Use single sentences to answer the following questions:

- (*a*) For what three purposes does a leaf use its pores?
- (*b*) Why does your mother hang wet clothes on the clothes line?
- (*c*) What do we call water that has turned into a gas?

- (*d*) Why is soil drier after a crop has been grown in it?
- (*e*) Why is it important to have some clay or some humus in the soil?
- (*f*) A farmer never attempts to water his crops in a dry season. Why is this?
- (*g*) In what country is the River Mississippi?
- (*h*) What is the main cause of the Mississippi floods?
- (*i*) Why do we plant conifers instead of hardwood trees?
- (*j*) Which conifer is not an evergreen tree?

(3) Try to gather a spray of larch that has on it:

- (*a*) The male flowers.
- (*b*) The female flowers.
- (*c*) The old cones.

Make a neat drawing of this.

(4) If you live in a part of the country where spruce-trees and Douglas fir-trees are to be found, gather a young shoot and a cone of each and make neat drawings of them.

(5) Match sticks are made of softwood, good furniture is made of hardwood. Examine the wooden articles you see every day either at home or in school and make one list of those that are made of softwood, and another of those that are made of hardwood. You should have at least five items under each heading.

(Note to the teacher—A 16-mm. film called *The River* tells the full story of the Mississippi floods. It can be hired from the National Film Library, 4 Great Russell St., W.C.1.)

12

Nature's Partnerships

But ask now the beasts, and they shall teach thee; and the fowls of the air, and they shall tell thee: or speak to the earth, and it shall teach thee: and the fishes of the sea shall declare unto thee.

THE BOOK OF JOB xii. 7–8.

YOU have already learnt something of the wonderful ways in which plants and animals depend on one another—flowers provide food for insects in many cases, and in return the insects help the flowers to produce strong and sturdy baby plants by carrying pollen from one bloom to another. The partnership between honey-bees and the flowers that give them nectar and pollen is even more remarkable than it appears to be at first sight. If you stand by a beehive on a fine sunny day you will be able to see the pollen gatherers returning home with their stores. Some of the returning workers are carrying small 'sacs' of pollen, one on each of their hind legs. If you look carefully at these you will see that the pollen gathered by any one bee is all of the same colour; that is to say, it has all been collected from one kind of flower. It may be yellow pollen from the charlock, black from the poppy, green from the blackberry flowers, or purple from the tall spires of the handsome rose bay willowherb, and so on; but each separate load has come from one sort of flower only, and the tiny gatherer has avoided paying any visits to blooms of a different kind.

Why is this? Does it make any difference to the bees back in the hive what sort of pollen is carried home? It does not. Indeed, pollen of all colours is mixed together in the storage cells. Remember, however, that this partnership between the bees and the flowers is not a one-sided affair. It is very important to the plants that their own particular kind of pollen should be carried from flower to flower. No useful purpose would be served by carrying pollen from, say, the rose bay willowherb to the pistil of a blackberry flower. Each flower must have its own sort of pollen if seeds are to be produced. By keeping to one kind of plant the bee is not only gathering food—it is also attending to the needs of the flowers themselves! This is a truly surprising arrangement; but it is only one of many. Nature is full of such partnerships.

The partnership between flowers and insects is of benefit to both.

There is a plant in America called the yucca. It looks rather like a small palm-tree and is sometimes grown in gardens in Britain; but it never produces any seeds in our country in spite of the fine flowers it bears. Can you guess why this is? It has a partner in the insect world. A certain moth; and this moth does not live in Britain, so that the yucca flower cannot be pollinated over here. In America, however, this insect is to be found, and when the yucca flower opens, the moth lays her eggs inside the pistil. *She* *then goes to the stamens and gathers pollen. She deliberately carries this pollen to the pistil and presses it into special grooves!* This is a most wonderful relationship. The plant could not produce seeds without the moth, and the moth could not produce young ones without the plant, because the tiny caterpillars cannot thrive on any plant except the yucca! You would never think that living things depended upon one another to this extent, yet it is true. The whole of natural life is fitted together in this way—much as the separate pieces of a jig-saw puzzle fit together to produce the complete picture.

BUMBLE-BEES AND THE RED CLOVER

Many farmers sow red clover in their 'seeds' *ley* as it is such a good hay plant, and, being one of the legumes, it enriches the soil with nitrate. If you examine one of its 'butterfly' flowers you will see that the petals all join together to form a long tube at the bottom of which is the *nectary*, where the sugary nectar is produced for the bees. But you do not see honey-bees visiting the flower!—and the pollinating is done by bumble-bees only. Why is this? There is obviously a partnership here between the red clover and the bumble-bee, but why doesn't the honey-bee join in? Honey-bees visit *white* clover often enough! The answer is that the sucking tongue of the honey-bee is not long enough to reach the nectar, whereas the longer tongue of the bumble-bee can get down the long *corolla* tube of the red clover quite easily. What would happen if the bumble-bees in Britain were all destroyed? The red clover would no longer have its partner to do the pollinating, so that it would not be able to produce many seeds. There is no doubt that the wild sorts of red clover would become quite rare in a very short time if the bumble-bees did vanish. (The farmer would still be able to grow his clover crops, however, as he can buy the seed from foreign countries like Italy.)

Is there any way in which bumble-bees are destroyed in Britain? There is, indeed. More than half the bumble-bees' nests are destroyed every year by the field-mouse, which feeds upon the cells and the young larvae. Nature, however, prevents these mice from becoming too common by providing natural enemies like the owl and certain hawks like the buzzard. The weasel and stoat also prey upon the field-mice. Do you see that there is a surprising connection here between the number of hawks, weasels, etc., and the amount of red clover that grows in our hedgerows? It is a sort of life-chain, and is a very good illustration of the relationships that exist between different living things. In this case the chain goes from hawks to mice, and then from the mice through the bumble-bees to the clover! Bird—rodent—insect—flower! The removal of the birds and animals of prey from a woodland area would certainly have a very definite effect—after a time—on the amount of wild red clover in that district! You cannot interfere with the

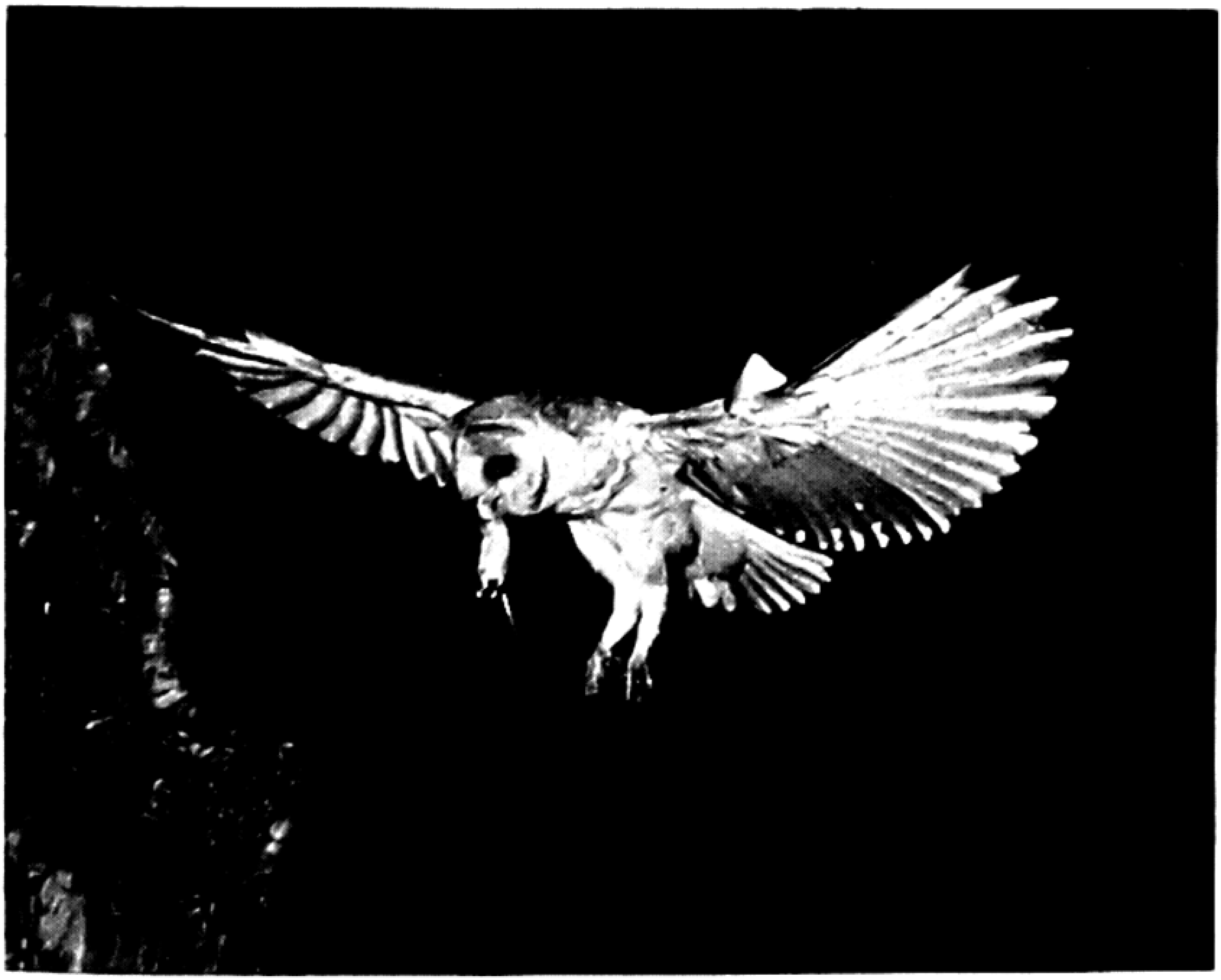
Red clover flowers are visited by bumble-bees —but never by honey-bees. Why is this?

BALANCE OF NATURE at one end of the 'chain' without producing an effect at the other. Let us have a look at a more serious result of this kind of interference with nature.

THE BALANCE OF NATURE

In order to preserve birds like pheasants and partridge for shooting, the gamekeeper spends a good deal of his time shooting any birds or other animals that would steal the eggs or chicks of his game-birds. For this reason most gamekeepers shoot all the owls, hawks, magpies, stoats, and weasels that they see. The removal of all these creatures of prey has an immediate effect on the next animals in the 'chain'—the rodents. The numbers of rodents such as the field-mouse and the vole are no longer kept in check by the owls, weasels, and so on, so that they increase very rapidly. Small numbers of these tiny creatures of the field and woodland—mice and voles—do little harm, but they cause a great deal of trouble if they become too numerous. They damage the farmer's crops and pasture fields, and they can ruin the young trees in newly planted woodlands by nipping off the topmost shoots. Notice the remarkable connecting chain that preserves the balance of Nature in this case: owls, hawks, weasels, etc.—mice and voles—crops and young plantations of trees.

Do you see from this that the farmer and the forester are benefited by the creatures of prey? Some farmers know this quite well, for have they not seen the kestrel hawk at threshing time hovering round the cornstack waiting for field-mice to appear? It is true that some of the owls and hawks will also kill an occasional chick in the farmyard, but the good that they do in keeping down the numbers of rodents like the field-mouse and the vole far outweighs small losses of this kind; and the wise farmer does not begrudge them an occasional tit-bit. Even the magpie does much more good than harm, and the only hawk that has a really black character so far as the farmer is concerned is the sparrow-hawk. This bird has something to its credit, however, for although it does certainly raid



This fine photograph of a flying bird proves that the barn-owl is a valuable friend to the farmer. The small rodent is a field-mouse.

the poultry runs, it also feeds on the small destructive creatures of the fields. But it should be kept away from the farm buildings. What you have to remember from all this is that nature always adjusts the numbers of plants and creatures in the fields and woods to suit her own purpose. If man comes along to alter this balance in any way, he should take care to find out first whether he will upset a chain of relationships by the changes that he makes. You see, if the gamekeeper ruthlessly shoots *all* the owls, hawks, magpies, stoats, and weasels, he will undoubtedly bring trouble to the farmers' crops and to the foresters' young plantations. And you learnt in the last chapter how a thoughtless and greedy interference with the balance of nature brought ruin to the cities of the River Mississippi. This does not mean that the gamekeeper must not try to preserve his partridges and pheasants by shooting a certain number of the birds of prey and other flesh-eating creatures. What it does mean is that he should not destroy them all; he must be satisfied to leave some of them to deal with the field-mice and voles, even if this means losing a few of his pheasant and partridge chicks.

Another important example of the balance of nature has to do with the many small birds of our hedgerows—the chaffinches, tits, blackbirds, robins, and so on. Most of these birds feed on seeds and fruits, but when they are feeding their nestlings they gather countless thousands of insects—caterpillars, flies, beetles, wireworms—anything, almost, that can be found in the insect world. As you know, farm crops are often attacked by insects of one sort or another, so that the hedgerow birds really perform a valuable service for the farmer. How does the balance of nature work in this case? When the farmer grows his crops he attracts the insects that feed upon them. For example, a field of turnips or kale will attract multitudes of cabbage-white butterflies whose caterpillars feed on the leaves of these crops; and grassland always attracts large numbers of an insect called the click-beetle, whose eggs hatch out to produce the damaging wireworm. These are only two of the countless insects that attack farm crops. As you know, these pests have to be dealt with by the farmer in spite of the help given by the birds, but if there were no birds at all, the insects would become a positive plague. Nature, you see, keeps a reasonable balance by providing the birds. These birds, however, need the hedgerows in which to build their nests—and here we have another 'chain' of relationships: crop—insect pest—birds—hedgerows. You can see quite well what would happen if we began to replace all our hedges with wire fences! There would be fewer birds, more insects, and poorer crops! What then does the wise farmer do? He keeps his hedgerows in good condition, and does not foolishly replace them all by wire fences. In these days of big farm machines like the combine harvester (which both cuts the corn and threshes it) there is a tendency to make bigger fields by uprooting many hedges. Already there are fewer birds in those parts of the country where this has been done—and the insect pests are increasing. This is another example of altering the balance of nature. Remember, then, that whenever an alteration is made in the realm of living things, it is bound to bring other changes in its train. The wise and thoughtful countryman knows all about nature's partnerships, and he always tries to work out what those other changes will be.

PARTNERSHIPS IN POND AND STREAM

In order to find out for yourselves some of the important connections between the plants and creatures that live under water, you are going to carry out some simple experiments. When you look into the clear waters of a still pond on a summer's day you will see that there are many insects swimming among the water plants. Indeed, if you take up a handful of the

If you wish to study the partnership between living things, why not start with the teeming life of an old pond?

'water weed' you are almost sure to find some insects clinging to it. Is there any partnership between these under-water plants and animals? Do they depend on one another in any way? Let us set up our experiments. You will need to collect some plants and insects from the pond and carry them home in jam jars. You can gather a handful of green *under*-water plants quite easily, but you will need to capture the insects—beetles, larvae, and so on. A good way to do this is to attach a long piece of strong string (about 10 ft. will do) to the neck of a jam jar; when you have done this, stand on the edge of the pond and hold the end of the string firmly in your hand. Now throw the jar as far as possible into the water and haul it in immediately. You will find that you can collect all sorts of strange creatures very quickly in this way.

TO SHOW THE PARTNERSHIP BETWEEN WATER PLANTS AND WATER ANIMALS

Experiment 1. Almost fill two 1-lb. jam jars with tap water, and add a *few* drops of soil indicator to each so that a blue colour is produced. Now put about a dozen water creatures into one of the jars—some tadpoles if you have them, and any beetles or larvae that you have collected. The bigger the creatures the more quickly the experiment will work. Set both jars on one side in a warm place (NOT in the sunlight, as this would make the animals uncomfortable), and take a look at the colour of the water from time to time. You may have to leave them for a whole day before you see that the blue colour in the jar containing the animals gradually changes to yellow. The water in the other jar—which contains no creatures—remains blue. What does this show?

The experiment proves that when animals live in water they cause it to become acid. Do you remember that water into which we blow the carbon dioxide of our breath also becomes acid? This is what happens in the case of the pond creatures. They are, of course, breathing all the time, and they use up the oxygen that is dissolved in the water. This is replaced by the carbon dioxide that is produced when they *respire*. Now let us see whether the water plants are able to affect the water in any way.

Water plants supply the needs of water animals; and water animals supply the needs of water plants. Here is a perfect partnership.

Experiment 2. Almost fill two small jars with tap water as before and add soil indicator to each. Use a *clean* tube of some kind to bubble your own breath into the water until the colour in both of the jars is turned to yellow. The water is now acid, and this shows that it contains carbon dioxide. Place a small handful of fresh 'water weed' into one of the jars and set them both *in the sunlight.* After a time, the yellow colour changes to blue! *This shows that all the carbon dioxide in the water has been used up by the plants.* Can you remember why this should be? The green leaves of the water plants need carbon dioxide in order to make sugar, and they get it from the water in which they live.

Here is an example of another wonderful partnership. If animals live in water where there are no plants they turn it acid and, also, they use up all the oxygen in it. Now both these *conditions* are harmful to the tiny creatures—they do not thrive properly in sour water, and they need fresh supplies of oxygen so that they can go on breathing. The plants growing in the pond, however, need the carbon dioxide and use it up; and in doing so they prevent the water from becoming acid! These plants also send out a good deal of oxygen when they are making sugar—much more oxygen than they need for their own breathing —so that the animals are constantly provided with fresh supplies of this important gas. You can now understand quite clearly why you should always have green water plants growing in your aquarium. The plants are partners in an important natural relationship. Indeed it is quite cruel to keep a goldfish in a bowl without green plants. It may live for a long time, but it will certainly feel very uncomfortable in the acid water, and it will have to come quite often to the surface of the water to suck in oxygen from the air. Sometimes thoughtless people also stand the goldfish bowl in the sunlight—so that the poor creature is made more uncomfortable still by the heat.[1]

AN EXPERIMENT TO SHOW THAT WATER PLANTS *DO* GIVE OFF OXYGEN DURING THE HOURS OF DAYLIGHT

Experiment 3. Two or three sprigs of any flourishing water weed[2] are necessary for this experiment, together with a glass funnel, a test-tube, and a beaker or other glass vessel into which the funnel will fit.

First of all, place the beaker, funnel, and test-tube into a deep bowl of water, and take care to see that no air bubbles remain in either the beaker or the test-tube.

Now while all the pieces of *apparatus* are still under water put the water plant sprigs into the beaker and cover with the funnel. Finally, place the test-tube over the stem of the funnel. You can now lift out the beaker and all its contents and set it on a sunny window ledge in a warm room. It is important to make sure that the test-tube is quite full of water at the beginning of the experiment. It is a good idea to put a *pinch* of bicarbonate of soda into the beakerful of water. This makes sure that you have plenty of carbon dioxide in the water; remember that the green leaves need carbon dioxide and water as well as sunshine in order to make sugar and give off oxygen.

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[1] Whenever we keep pets of any kind, we should remember that they depend upon us for their well-being; and we should do all we can to find out what they need, so that they can be kept well and happy. Dumb creatures cannot tell us of their discomforts, and they often suffer in silence until they become ill. We must give them our careful thought at all times, otherwise it is very selfish to keep them at all. But if we *do* look after them properly they repay us for the trouble. Not only do they look more attractive, they are also more lively and interesting in their behaviour.

[2] Canadian water weed is one of the best, but watercress will do quite well.

Before very long bubbles of oxygen will begin to rise into the test-tube. If you allow enough of the gas to collect (say half a test-tubeful), you can test that it does contain a good deal of oxygen by removing the test-tube and inserting a glowing splinter into it.

There are, of course, many other examples of living partnerships in the water world; but this is the most important one. Water life is very well balanced by nature—and creatures that depend on one another for food will be found living in the same pools and streams. Whenever you find the PIKE, for example, —this is the 'hawk' of the water world—you may be sure that there are many smaller fish on which the pike feeds. The presence of this *voracious* fish ensures that the smaller fish shall not upset the balance of life in the pool by becoming too numerous.

If you wish to become a 'nature detective' you cannot do better than make a study of these many relationships. The countryside is full of clues. A kingfisher flashing along a stream shows you that there are fish in that stream, otherwise the kingfisher would not be there. If you see that the bark of the upper branches of a young tree has been nibbled away, you may be sure that there are squirrels not far away. Each stretch of country through which you go has its own design. It is a pattern made up of many parts: each bird, each insect, each flower or tree—every living thing—lives a life that is closely woven into the lives of all the others. And man's life, too, is part of that picture—he also is a part of nature's scheme; and if he is to live his life successfully he must take care to preserve the balance of nature. He may need to *alter* the pattern—indeed that is just exactly what the farmer does—but he must take care not to destroy it altogether. If we *co-operate* with nature she will bring great benefit to us, but if we destroy her pattern, as the Americans did when they cut down all the Mississippi forests, she does not hesitate to destroy us with floods and famine.

THINGS TO DO

(1) Write a composition entitled 'Do Hawks and Owls help the Farmer?' Tell about the good they do, and compare this with the trouble they cause. Finish up by saying whether they are a help or a hindrance.

(2) Write single sentences in answer to the following questions:

- (*a*) What value do bees and flowers get from their partnership?
- (*b*) Why don't honey-bees visit red clover?
- (*c*) What animal destroys bumble-bees' nests?
- (*d*) What kinds of things do stoats and weasels eat?
- (*e*) How does nature prevent the rodents from becoming too numerous?
- (*f*) Why shouldn't the gamekeeper shoot all the owls, hawks, stoats, etc.?
- (*g*) In what way do small birds help the farmer?
- (*h*) Why are hedges better than wire fences on a farm?
- (*i*) What is the value of green water plants to water creatures?
- (*j*) Water creatures provide water plants with an important substance. What is it?

(3) When owls have partly digested their food, they 'throw up' the indigestible portions in the form of small oval 'bundles' called pellets. These are usually about an

inch or two long and can often be found fresh each day at the foot of a tree in which the owl roosts. Search the woodlands for these pellets and try to find out from them what owls eat. When you find one spread it out on a piece of paper and make a careful list of what it contains.

(4) Make your own aquarium in a large jam jar. Put some sand or a *little* pond mud at the bottom, and set your plants in this before you pour in some of the pond or river water. Place the jar by a window that does not face the sun. Now catch about twelve water creatures, put them in the jar, and watch their behaviour each day. Find out the names of the creatures, and make a list of them in your book. (If you catch a newt, you will need to put a piece of rock in your jar, so that this water lizard can climb out into the air from time to time. After two weeks put the creatures back into the pond.)

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